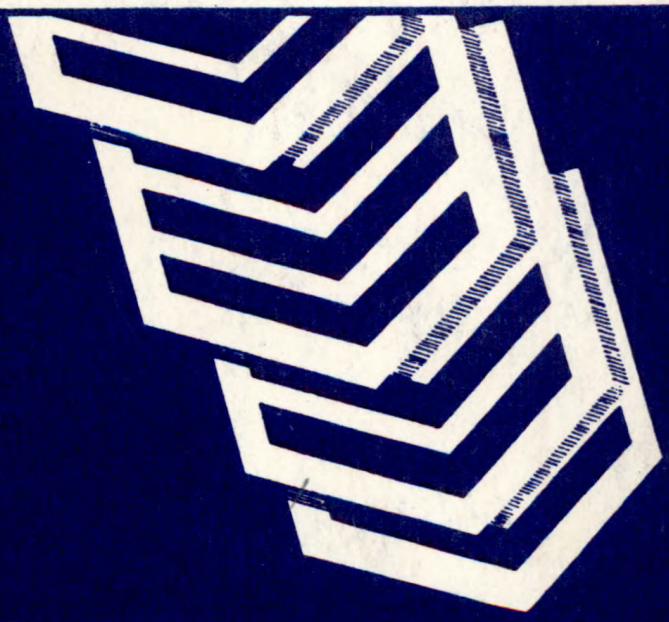
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USE OF BLUEPRINTS



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USE OF BLUEPRINTS

PREPARED BY
STANDARDS AND CURRICULUM DIVISION
TRAINING
BUREAU OF NAVAL PERSONNEL



NAVY TRAINING COURSES
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PREFACE

This book is prepared as a basic reference for those enliste men of the Navy whose duties require them to read and us blueprints.

A knowledge of blueprint reading is of major importance t those men in the artificer and seaman branches responsible fo the operation, maintenance, and repair of equipment. Whethe the job involves work on engines, gun mounts, boilers, steerin gear, winches, or computers, the Navy technician consults blue prints for the information he needs to keep the gear and equip ment in shipshape condition.

As the man studies this book, he should refer frequently t typical blueprints of Navy installations and equipment. Suc prints are available in technical manuals published by both th Navy and the manufacturers of Navy equipment.

The book begins with a broad picture of the uses and kind of blueprints. It explains fully the language of the blueprint— lines, sections, symbols, dimensions, conventions, notes, an titles. Emphasis is placed on the reading and use of ortho graphic detail drawings and the proper procedure to follo when making layouts on material. One practice layout job i described step-by-step, and another is inserted as a challeng to the reader.

As one of several BASIC NAVY TRAINING COURSES, this boo was prepared in the Training Courses Unit, Standards an Curriculum Division, Training, Bureau of Naval Personnel.

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TABLE OF CONTENTS

Page

Preface II

CHAPTER 1

Background for blueprints 1

CHAPTER 2

It's all how you look at it 7

CHAPTER 3

Lines and sections 17

CHAPTER 4

The working drawing tells everything 29

CHAPTER 5

Read it yourself 41

CHAPTER 6

Rules for layout tools 49

CHAPTER 7

Lay it out 63

CHAPTER 8

Tin-bender specials—developments 75

CHAPTER 9

Electrical blueprints 89

CHAPTER 10

Reading diagrams 95

APPENDIX I

Abbreviations in common use 103

APPENDIX II

Fractions and decimal equivalents 106

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TABLE OF CONTENTS (Cont'd)

APPENDIX III

Twist drill sizes.....107

APPENDIX IV

Standard wire gages.....108

QUIZ

How well do you know Use of Blueprints.....109

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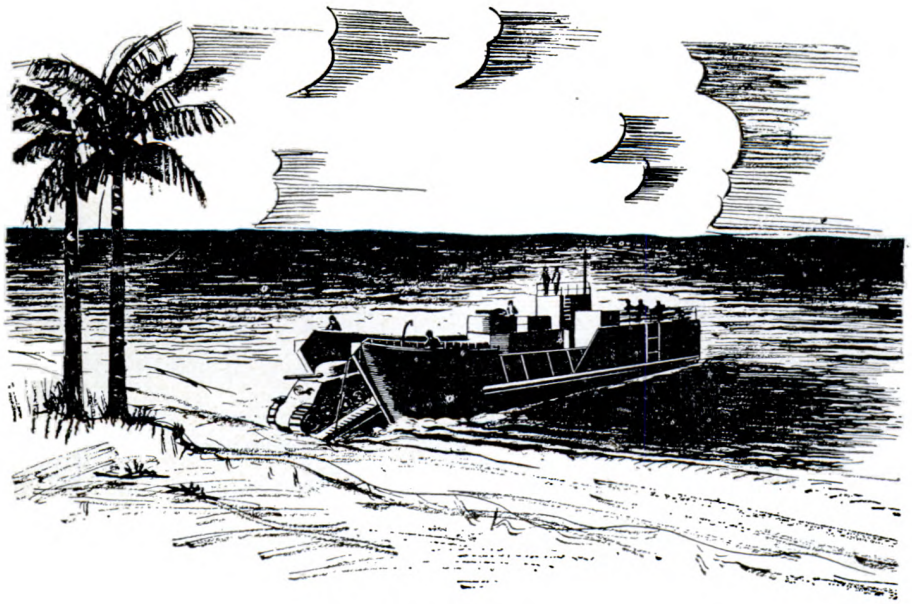
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CHAPTER 1

BACKGROUND FOR BLUEPRINTS

WHAT ARE THEY?

Blueprints are the road maps of modern civilization. Look at the Empire State Building, the Golden Gate Bridge, and the USS MISSOURI. Each one of them was built from blueprints—thousands, tons, acres of blueprints.

The ships, planes, and guns of the Navy were built from blueprints. They are operated, checked, cleaned, and lubricated according to information found on blueprints. When mechanisms fail in service or are damaged in battle, blueprints are broken out to aid the repair crews. When new parts must be made in the shops, blueprints provide the necessary information.

HOW ARE THEY MADE?

Blueprints are exact copies of MECHANICAL DRAWINGS. The drawings are accurately drawn to scale. Blueprints, or just "prints" as they are often called, are made from these drawings in much the same way that photographs are made from negatives.

The negative for the blueprint is known as a TRAC-

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ING. It is made by placing a sheet of special translucent tracing paper or cloth over the drawing. Everything on the drawing is traced on the tracing paper or cloth with black waterproof ink or a special black pencil. After the tracing is completed it is checked and the original drawing filed for future use. Some drawings are made directly on the tracing material in pencil, then traced with ink or with the special black pencil. This short-cut saves time and material and is satisfactory for most jobs.

Now the tracing is placed on a sheet of clear glass mounted in a special frame. The tracing is covered with a sheet of sensitized light-green blueprint paper. A padded back is secured behind the blueprint paper to keep the two sheets together. The front of the frame is then exposed to a strong light, which penetrates the tracing at all parts not covered by lines and causes a chemical action on the print paper. There is no chemical action under the lines of the tracing because the black lines block off the light.

After the proper exposure, the print is removed and washed in clear water to remove the unexposed chemical. The exposed portions of the print paper turn a deep blue during the washing. The lines will be white. Sometimes the print is first washed in a weak solution of bichromate of potash to intensify the blue color. If this solution is used, the print must again be washed in clear water.

Any number of prints can be made from one tracing, if it is handled carefully.

When a large number of prints are required they are made in a special blueprinting machine, but the same principle is involved.

ARE BLUEPRINTS BLUE?

Not necessarily so! Blueprints aren't always blue. All kinds of reproduced drawings are commonly referred to as blueprints or just prints. They may be white, brown, black, gray, or other colors. The differ-

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ences lie in the kinds of papers and in the development processes.

You should be able to recognize other prints, because you may be working with some of them.

Black-and-white prints have BLACK LINES ON WHITE BACKGROUND.

Ammonia prints, or "ozalids," have BLACK, MAROON, PURPLE or BLUE LINES on WHITE BACKGROUND.

Van Dykes have WHITE LINES on DARK BROWN BACKGROUND.

Negative photostats have WHITE LINES on DARK GRAY BACKGROUND.

A BLUEPRINT'S LIFE HISTORY

You may take blueprints for granted, but they can have quite a history. Navy blueprints are born when the need arises for something new and different. Perhaps you have seen an LCT ram through the surf and up on a beach, lower its ramp, unload its fighting men and equipment, and back off to return for another cargo. Blueprints played an important role in the development of that LCT.

Before the war reached the Pacific, we had no satisfactory landing craft. It was soon apparent that a specially designed, light draft boat was needed to make landings on the shallow beaches.

Marine engineers and naval architects were put to work on this pressing problem. SKETCHES were worked out, revised, and re-drawn. Many sketches were discarded along the way. The best features of many ideas and sketches were worked into one DESIGN. Naval architects and engineers checked the design and made PRELIMINARY DRAWINGS.

From these drawings PRELIMINARY BLUEPRINTS were made and the construction of TEST MODELS begun. These full-size test models were tried out under all extremes of battle conditions. When all the "bugs" were eliminated, the LCT could take plenty of punishment and still keep on going. Then FINAL

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DRAWINGS were made, checked carefully and blueprinted.

Complete sets of these FINAL BLUEPRINTS were sent to the shipyards and the LCTS soon began to go down to the sea to fight.

Blueprints go right along when a ship or boat goes into service. These blueprints are used for maintenance and repair.

BLUEPRINTS YOU WILL USE

Many of our fighting ships are so large and have so many sections, divisions, compartments, passageways, and ladders that the members of the crew need maps to find their way around. These maps or blueprints are PLAN VIEWS and show position, location, and use of the various parts of the ship.

You will use plan views to find your duty and battle stations, the sick bay, barber shop, tailor shop, and bakery. Other plan views will show the location of watertight doors and hatches, life rafts and boats, battle dressing stations, and firefighting equipment. Still others will show water mains, power lines, air lines, ventilating systems, drainage systems, and fire control systems.

If you are a member of a DAMAGE CONTROL PARTY, you need to study all these plan views. You must be able to reach the scene of trouble on the double and not have to waste time looking up its location.

A separate installation, such as a 3″ 50 gun and mount, will be shown on an ASSEMBLY PRINT. It will show the various parts of the mechanism, how the parts fit together, and their relations to each other.

Individual mechanisms, such as motors, pumps, mounts, and indicators will be shown on SUB-ASSEMBLY PRINTS. These show location, shape, size, and relationships of the parts of the sub-assembly unit.

Assembly and sub-assembly prints are used to learn the operation and maintenance of machines and equipment.

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When you are required to make a certain part you will use a DETAIL PRINT. This print will give you all the information you need to make a new part or piece. A detail sheet will show one large part or several small parts. It shows size, shape, kind of material, and method of finishing. It is indispensable to the man in the shop.

Remember that PLAN VIEWS serve as maps, that ASSEMBLY and SUB-ASSEMBLY PRINTS show how parts fit together, and that DETAIL PRINTS show everything needed to make a certain part or piece.

HANDLE WITH CARE

Blueprints are not just scraps of paper. They are valuable permanent records and can be used again and again if you take care of them. There are a few simple rules for getting the best results from them.

KEEP THEM OUT OF STRONG SUNLIGHT — they might fade.

Don't allow them to get wet or grease-smudged.

Don't pencil or crayon notations without proper authority. If you should get instructions to mark a blueprint, use a YELLOW pencil. Ordinary (black lead) pencil marks are hard to see on a colored background.

NEVER MEASURE DISTANCE ON A BLUEPRINT! If you can't find a dimension on one view, look at another view. If you still can't find it, ASK SOMEONE WHO KNOWS.

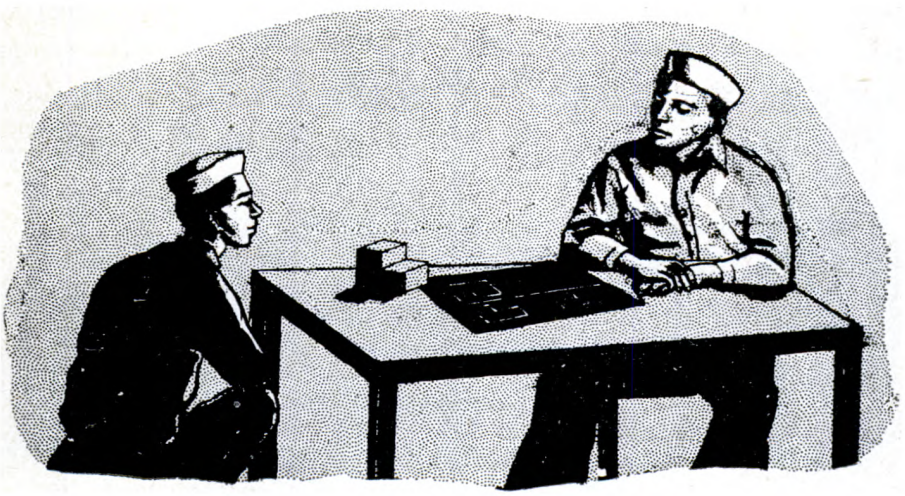
WHY NOT MEASURE?—The original mechanical drawings might not have been drawn absolutely to scale. The print paper may have shrunk or stretched. You can't take chances!

Take care of your blueprints just as you do your girl friend's picture. Stow them in their proper place so they'll be ready to look at next time.

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CHAPTER 2

IT'S ALL HOW YOU LOOK AT IT

ALL IN ONE

A PHOTOGRAPH of an object gives you a good idea of the shape and size of that object and the relationships of its various parts. The camera brings all visible parts into one picture view on one plane. It records pictures of objects much as your eyes see them. The hitch is that the camera picture is deceptive just as your eyes are deceptive. Your eyes may be 20/20 but they're not to be trusted—not completely anyway. And why not? Just recall the last time you looked down a straight stretch of railroad. Your eyes told you that the tracks came together at a distant point. You KNEW the tracks were parallel so you didn't believe your eyes. The camera records this deceptive appearance, so don't trust pictures too far.

This deceptive feature of photographs prevents their use where ACCURATE blueprints are necessary. The lines on a photograph do not register directly the TRUE LENGTH and SHAPE. Blueprints made from photographs are not satisfactory for use in construction and repair of ships, engines, and machines.

Photographic blueprints are valuable visual aids

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when used to show GENERAL LOCATION, FUNCTION, and APPEARANCE of parts and assemblies. They are often used to show the special characteristics of parts as in figure 1.

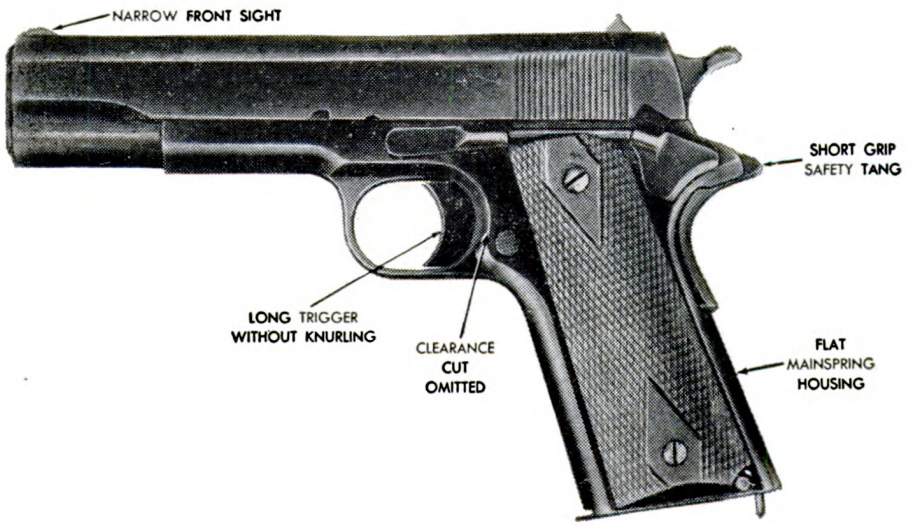


Figure 1.—Exterior characteristics of .45 pistol.

OPERATION STEPS are often shown by a series or sequence of photo prints. You may learn to take a mechanism apart and re-assemble it by using photo prints as a guide.

EXPLODED VIEWS

Another valuable use of the photo is for EXPLODED VIEWS that show locations of parts. Figure 2 shows two exploded views of the .45 caliber automatic pistol. Notice how the parts are spread out in line to clearly show each part's relationship to the other parts. These views are also known as TRAIN VIEWS.

IMITATION PHOTOGRAPHS—PERSPECTIVES

You can't take a photograph of something that doesn't exist! Often it is desirable to have a picture of a new type of boat or machine before such an article has been manufactured. The draftsman uses his mechanical drawing tools to create pictures.

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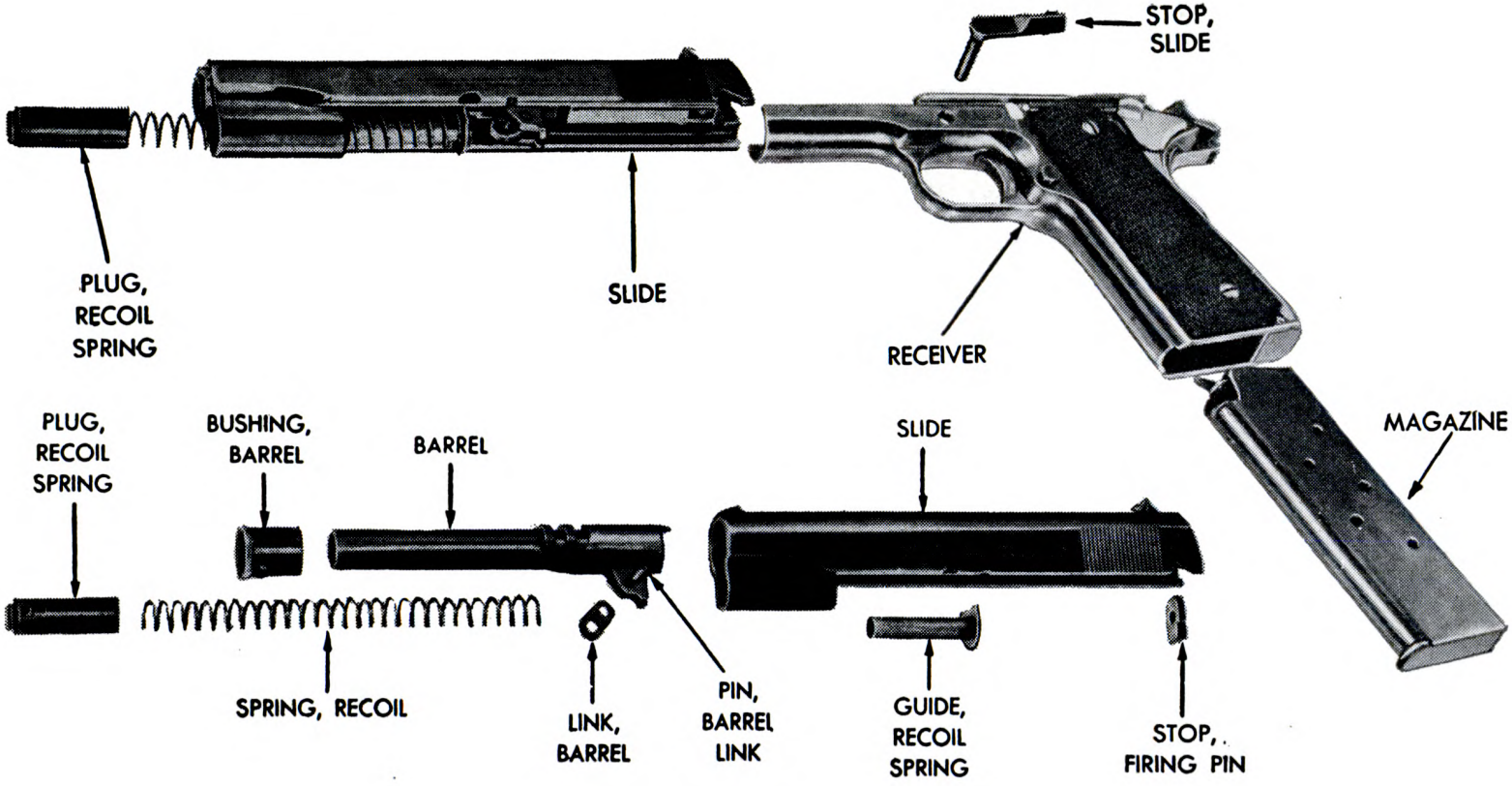


Figure 2.—Exploded views.

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These substitute pictures are called PERSPECTIVES. On a perspective, lines that are really parallel would run together if extended. Perspectives are excellent substitutes for photographs and may be used in the same manner. You will not use either of them for CONSTRUCTION or REPAIR BLUEPRINTS.

ANOTHER IMITATION—THE ISOMETRIC

The isometric is somewhat like the photograph and the perspective. All its lines representing horizontal and vertical lines on an object have true length. Vertical lines are shown in a vertical position but lines representing horizontal lines are drawn at an angle of 30° with the horizontal. Vertical lines and lines representing horizontals are known as ISOMETRIC LINES. In figure 3, all lines, except lines *A* and *B*, have true length because they are horizontal and vertical lines on the object. Lines *A* and *B* are not isometric lines and their lengths are not true.

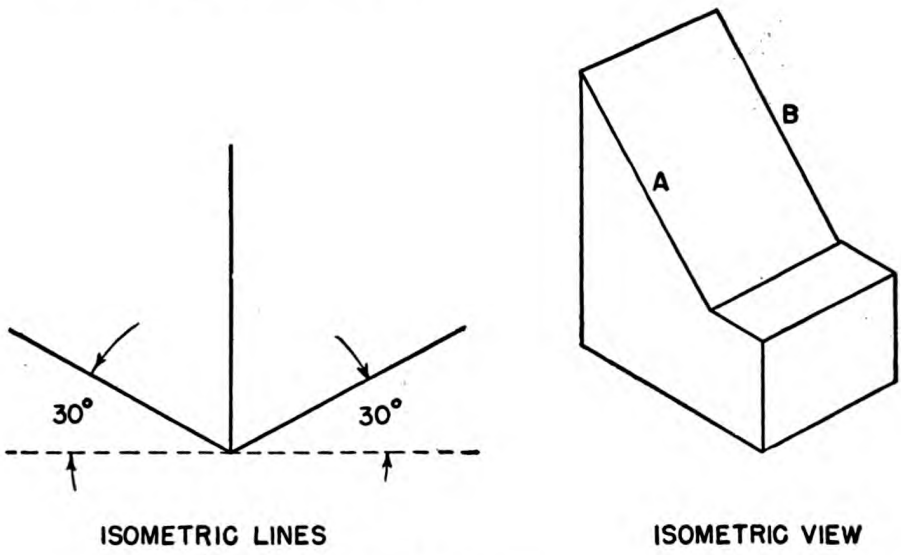


Figure 3.—Isometrics.

Isometrics have much the same use as other picture drawings. In addition they may be dimensioned—and blueprints of these drawings may be used for making SIMPLE objects. But isometrics cannot be used alone

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for complicated parts or structures. They may be used as an aid in clarifying the ACCURATE ORTHOGRAPHIC DRAWINGS that are the foundation of all construction blueprints.

TRUE VIEWS—ORTHOGRAPHICS

Blueprints, which furnish COMPLETE INFORMATION for construction and repair, present an object in its true proportions. Such prints are copies of mechan-

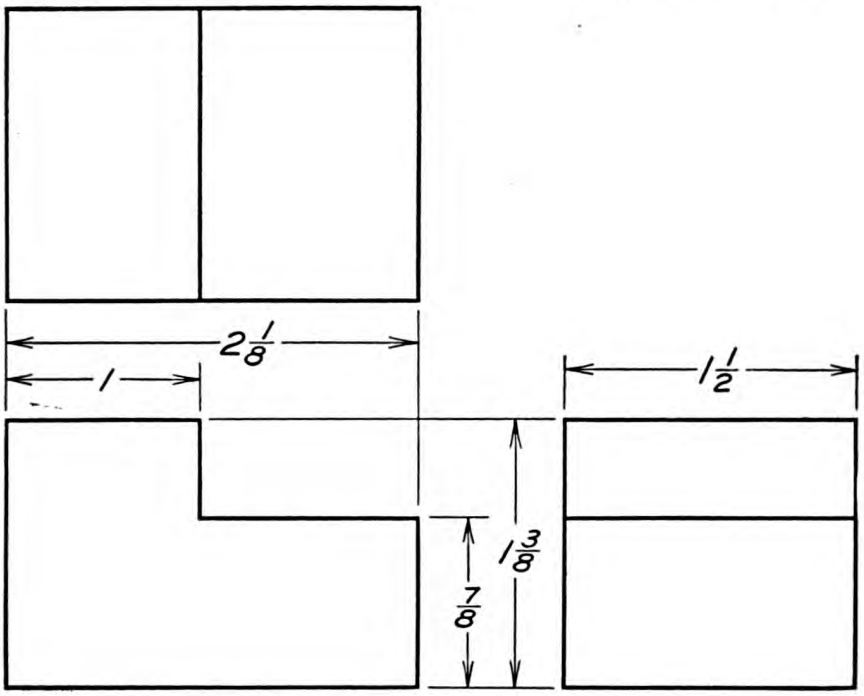


Figure 4.—The orthographic views.

ically drawn ORTHOGRAPHIC VIEWS. These views are ACCURATE and indicate TRUE SHAPE AND SIZE.

When you study orthographics, look at one view at a time. To get a good idea of a PT boat you would look at it from either port or starboard, then from dead ahead or astern, then from topside. By observing from many points you obtain a clear understanding of the whole boat. This is the basic principle of orthographics.

You can see a surface of an object in its true shape and size only by LOOKING DIRECTLY at that surface.

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Your line of sight must be PERPENDICULAR to the surface AT ALL POINTS on the surface. Only then can you tell the true size and shape of each surface. When these views of the various surfaces are placed on paper, their proper relationship is maintained by the proper arrangement of the views.

ORDERLY VIEW ARRANGEMENT

Study the arrangement of the three views in figure 4. The FRONT VIEW is the starting place. Concentrate your eyes on it. It was selected for the front view because it shows the most characteristic feature of the object—the notch.

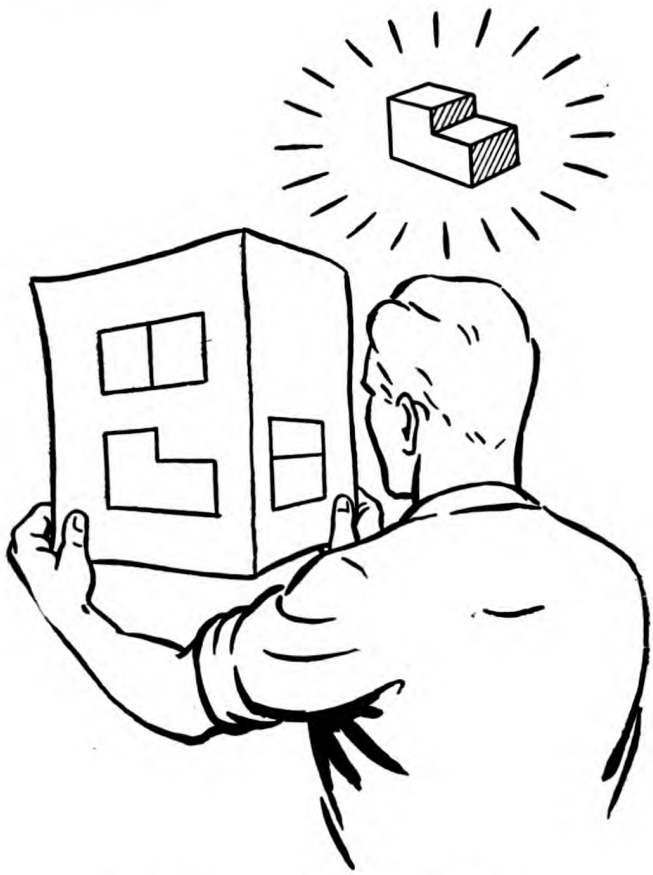


Figure 5.—Trick to help visualize blueprint.

The RIGHT SIDE VIEW is projected directly to the right of the front view. Some of the lines on the

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right side view lie along extensions of lines on the front view.

Notice that the TOP VIEW is placed directly above

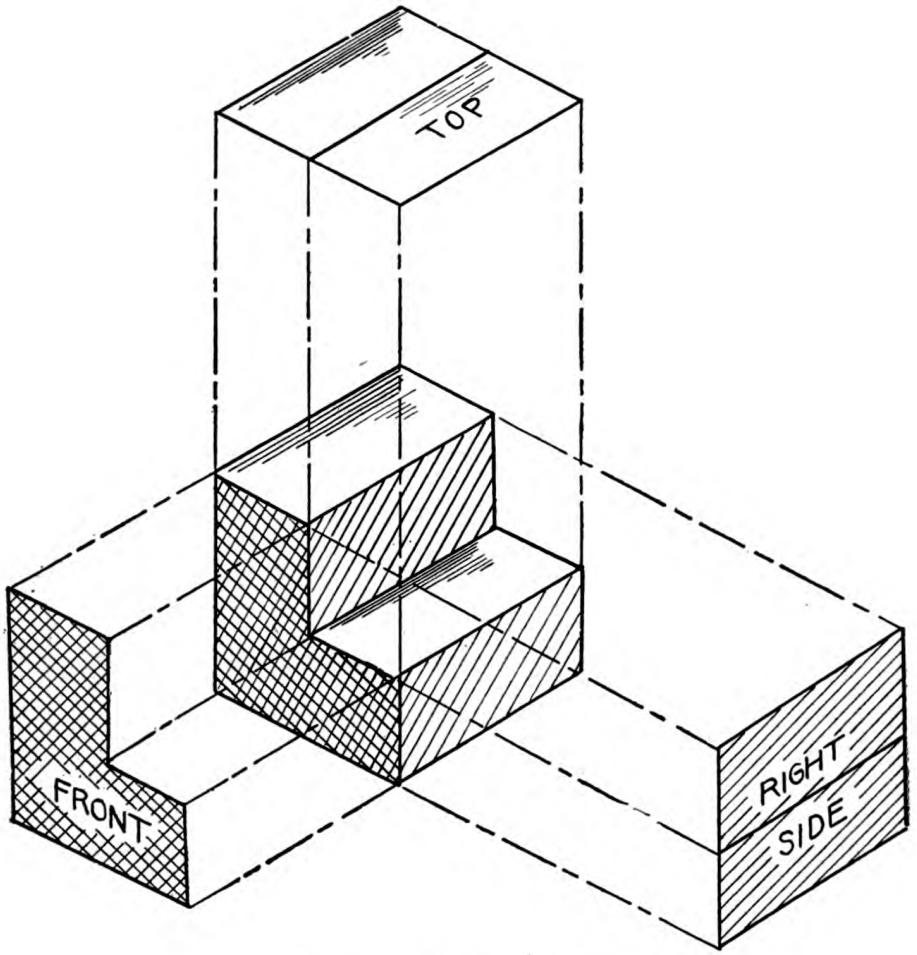


Figure 6.—Pull off the views.

the front view and that some of its lines lie along extensions of lines on the front view.

After you study each view, try to imagine or visualize the appearance of the object. If you have trouble try the trick shown in figure 5.

Fold the sheet between the front and right side views. That will give you a rough idea of the shape of the object as it appears in three dimensions. Figure 6 shows how the views are "pulled" from the object.

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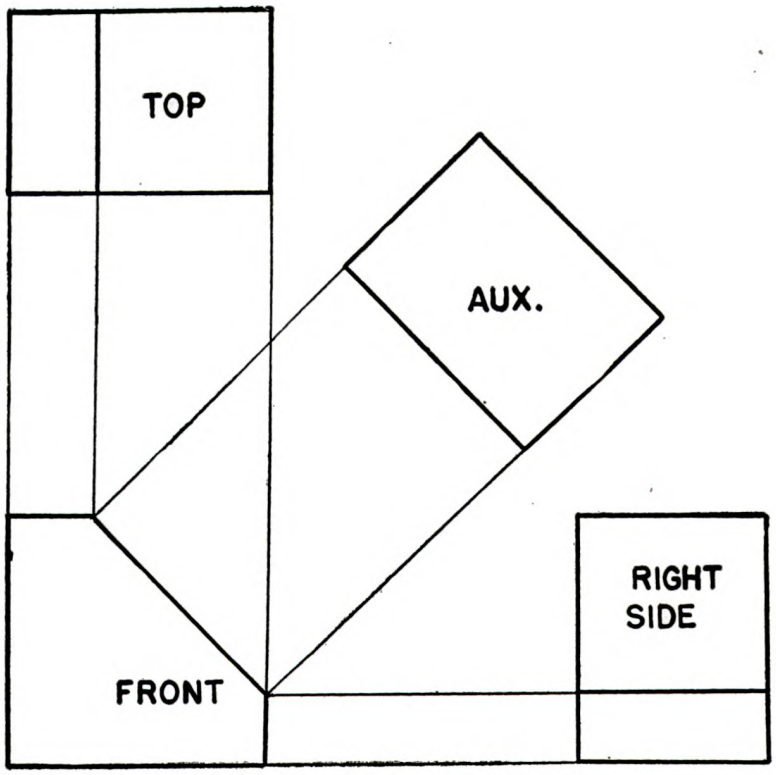


Figure 7.—Auxiliary view arrangement.

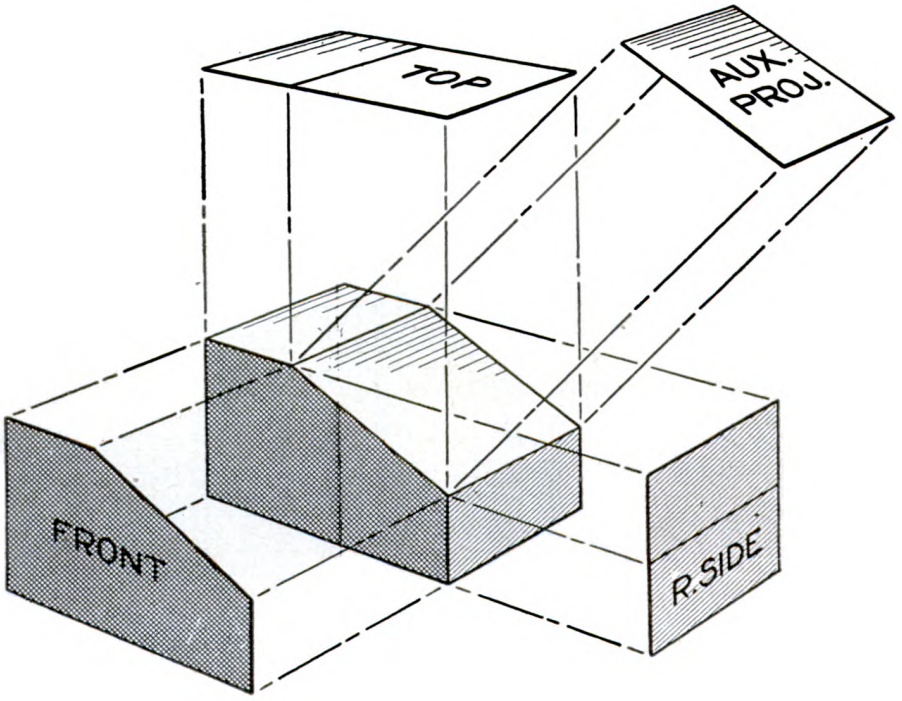


Figure 8.—Auxiliary projection principle.

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AUXILIARY PROJECTION

Look directly at the front view of figure 7. Notice the INCLINED SURFACE. Now look at the right side view and the top view. The inclined surface appears foreshortened—not its true size. For a case like this the draftsman uses a special helping view, known as an AUXILIARY. It is obtained by looking directly at

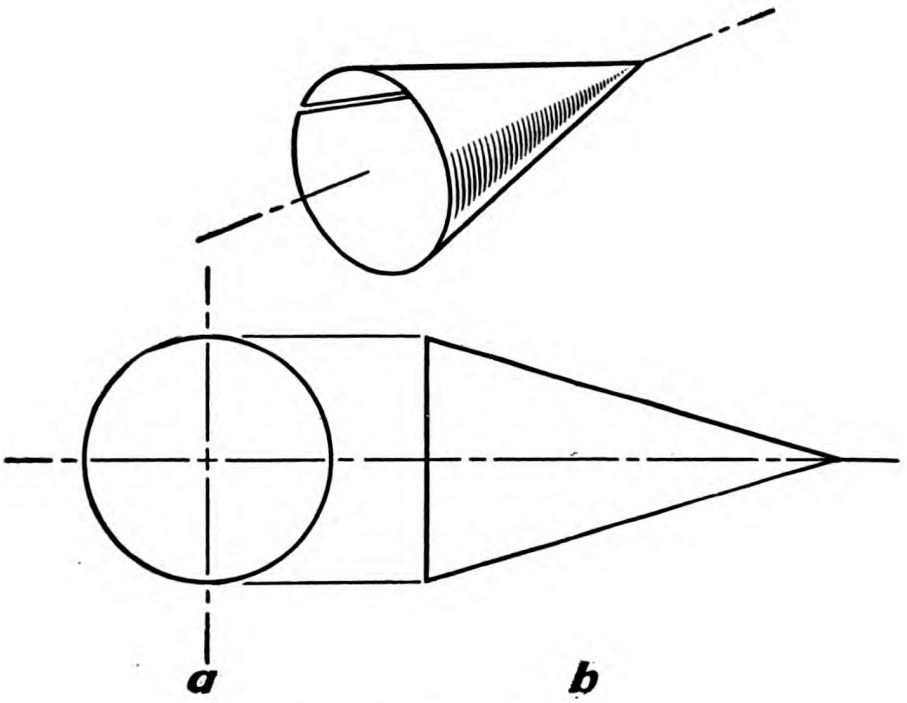


Figure 9.—Unroll the cone.

the inclined surface. This orthographic auxiliary is true and accurate and provides a reliable view of an inclined surface. The principle of the auxiliary is clearly shown in figure 8.

HOW ABOUT CURVES?

If you look at the front view, *a,* in figure 9, you can see that the object has a curved surface. If you look at the right side view, *b,* you'll see a triangle without any curve. The orthographic technique worked fine

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as long as you had a flat surface—but it is unable to show the curve of a curved surface.

In order to make a cone like the one shown in figure 9, you'll have to find the shape of the curved surface as it is laid out in the flat. You can find this shape by UNROLLING the cone. This calls for a DEVELOPMENT and you will find information on this when you come to Chapter 8.

TEST YOURSELF

Sketch three views of each object in figure 10. Start with a front view.

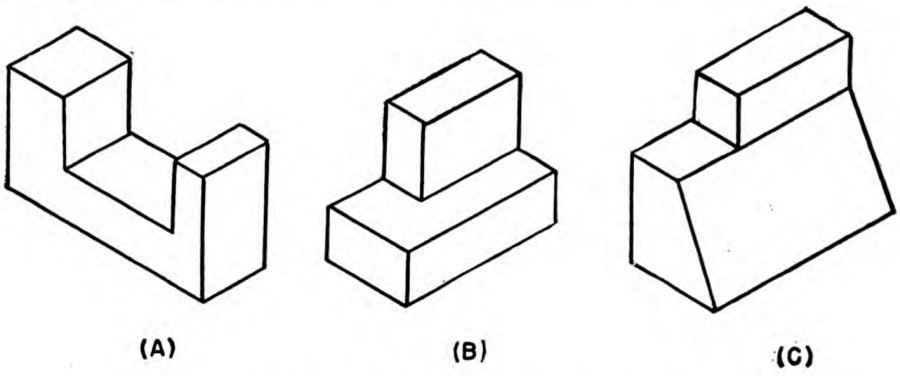


Figure 10.—Orthographics from isometrics.

Now sketch isometrics from the three-view orthographics in figure 11. Ask some of your shipmates,

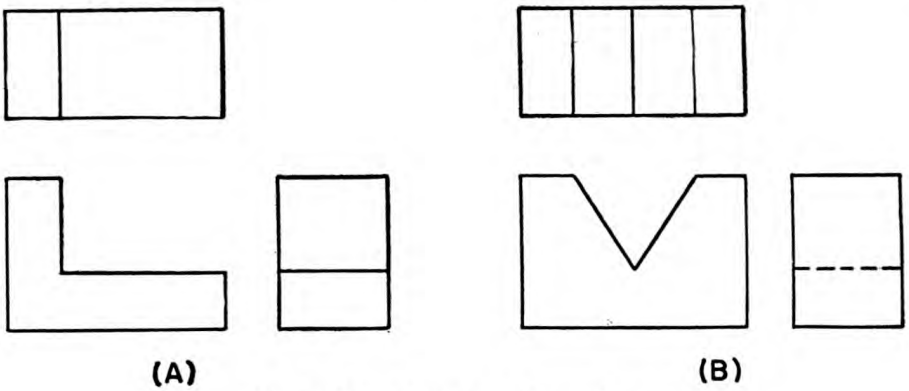
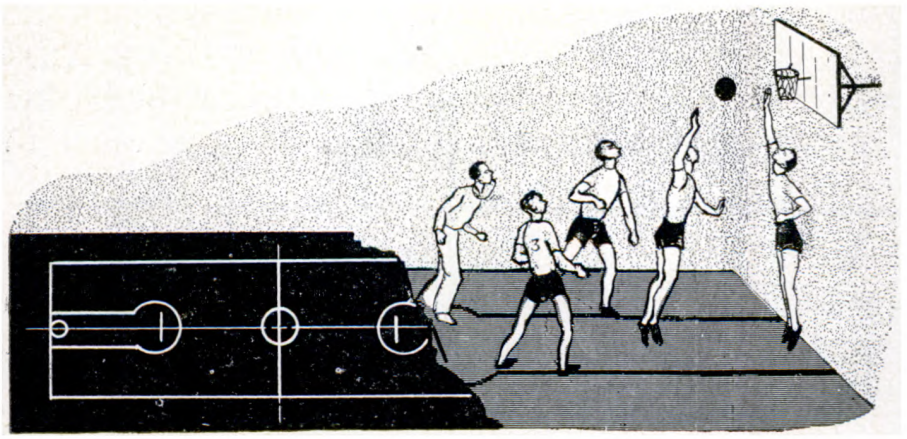


Figure 11.—Change to isometrics.

who understand blueprint reading, to check your work and give you additional problems.

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CHAPTER 3

LINES AND SECTIONS

DRAFTSMAN'S LANGUAGE

LINES are the "common words" of the draftsman. He DRAWS his language. He must place a lot of information in a small space so he uses as few words as possible. The draftsman's drawings are composed of lines of different construction, each line with a special meaning.

The lines on drawings and blueprints are standardized. You need to learn the appearance and use of these lines to be able to understand blueprints.

Here, you will concentrate particularly on the types of lines shown on blueprints of PARTS and ASSEMBLIES of machines, guns, engines and other equipment.

LINE USE

A basketball court is laid out with LINES. There are boundary lines, center circle lines, and free-throw lines. The basketball court is really a full-size, top view orthographic made with lines. The lines may be different lengths, widths, colors, and shapes for different uses. This same principle is used on mechanical drawing—so you need not be confused when you try to read drawings.

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Take a look at some of the typical lines—

On a blueprint, the draftsman uses OUTLINE LINES. They correspond to the boundary lines of the basketball court. These HEAVY, SOLID LINES represent the

OUTLINE

edges and surfaces that are visible from the angle at which the view is drawn. You wouldn't be able to identify an object without the outline lines.

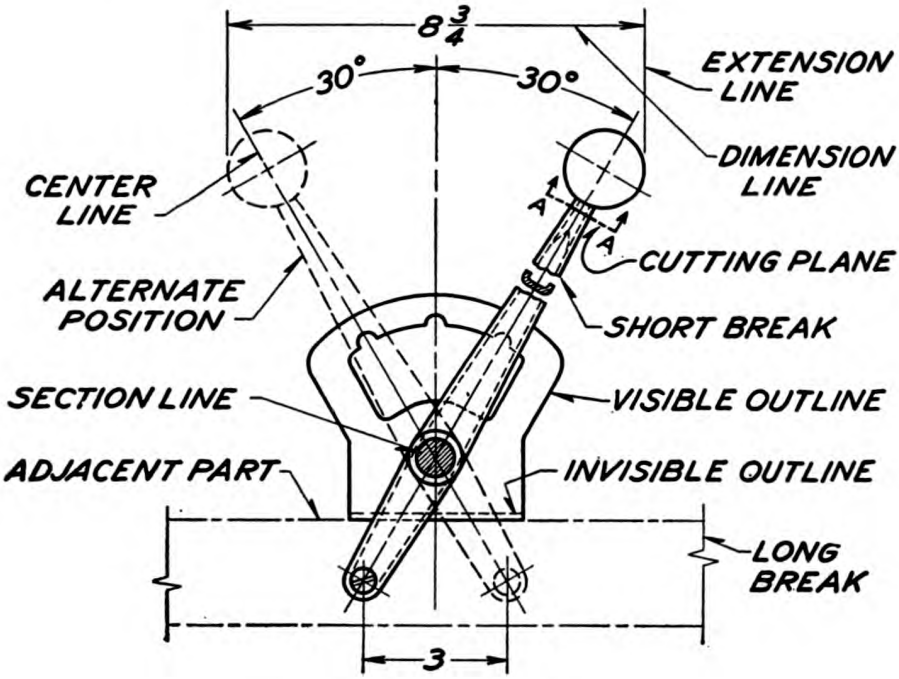


Figure 12.—Correct use of lines.

If you could look right through an object you would see other lines in the object and on the back surface. You know these lines are there but you can't see them.

HIDDEN LINE

To represent these invisible lines the draftsman uses a MEDIUM-WEIGHT BROKEN LINE. It is made with a series of short dashes all the same length.

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These dashed lines are called HIDDEN LINES. They represent edges of surfaces behind the view which is represented by the regular outline lines. Find both kinds of lines on the drawing in figure 12. Notice that these two kinds of lines form the backbone of the drawing.

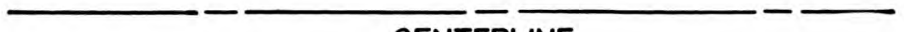
ALTERNATE POSITION LINES show possible alternate positions of moving parts. The lever in figure 12 is shown in a right-hand position. But the alternate position lines tell you that it moves to the left, swinging through an arc of 60°. The dashes of this line are



ALTERNATE POSITION LINE

the same weight as hidden lines but are TWICE as long.

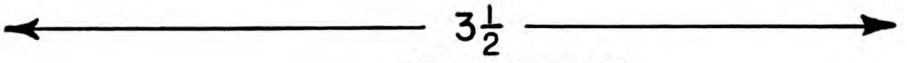
To locate the center of a circle or arc, CENTERLINES are used. They're also used to divide drawings into equal or symetrical parts. You'll find these lines help-



CENTERLINE

ful in dimensioning and lining up views. Notice that the centerline is a light weight line with alternate long and short dashes. Center lines are always used to locate the center of a round hole.

Size is indicated on drawings by dimensions. Navy blueprints are usually dimensioned in inches. Size



DIMENSION LINE

dimensions are placed in a break in the DIMENSION LINE. Some dimensions are placed between arrowhead tipped lines. In either case, the dimension distance is from the POINT of one arrowhead to the POINT of the other arrowhead.

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To keep the dimensions clear of the view they are placed outside the view. Sometimes it's necessary to put dimensions inside the outline, but it's better practice to keep them outside. EXTENSION LINES, very light in weight, are extended from lines of the outline. They are started about 1/16 inch away from the view outline.

Notice how the different kinds of lines are labeled on figure 12. Each name is tied to the proper line by a LEADER. Either straight or curved line leaders may



LEADERS

be used. A straight line leader is slanted at an angle to the lines on the drawing. This is done to keep you from getting mixed up.

The pointing end of the leader is usually tipped with an arrowhead of one of the types shown. The note or name used with the leader is located in a clear space that is not covered by the views of the drawing or the dimension lines of the drawing.

Sometimes the draftsman is cramped for space. If he drew the whole object, he would either run off the paper or have undersize views. But he can use LONG BREAK LINES to tell you that he has shortened that part.



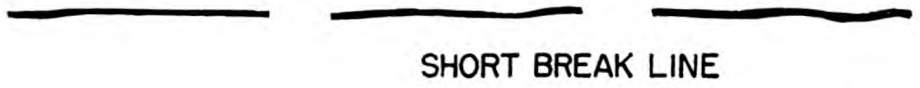
LONG BREAK LINE

The long break line is a space saver for the draftsman. It does not change the actual length indicated by the dimension.

SHORT BREAK LINES tell you that the draftsman has removed part of an outer surface to reveal the inside

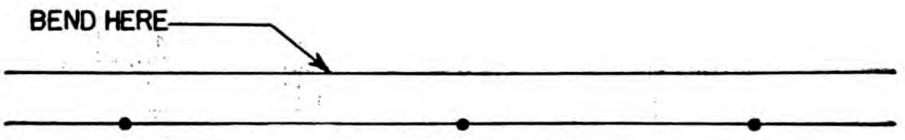
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structure. (Notice the two short break lines in figure 12.) You will find that short break lines usually come in pairs.



SHORT BREAK LINE

To indicate where thin metal is to be bent the draftsman uses bend lines. Some draftsmen place dots on the line instead of the note "bend here."



BEND LINES

COMPARATIVE WEIGHT OF LINES

Learn to distinguish lines by their weight or width. Lines are referred to as being heavy, medium, or

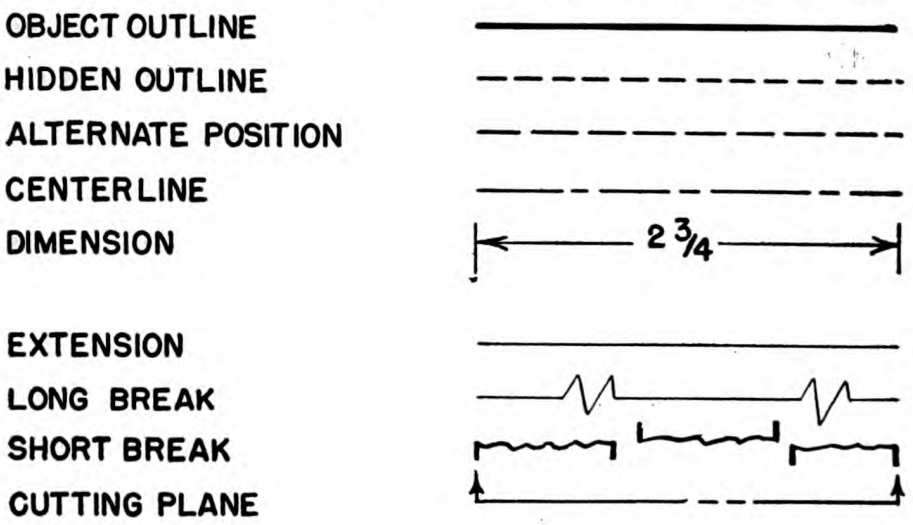


Figure 13.—Comparison of line weights.

light. Figure 13 compares the weights of the lines you have learned in this chapter. They're your ABC's, so train your eyes to instantly recognize any kind of line.

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LOOK INSIDE—SECTIONS

When you first see a new type of boat, ship, or plane you like to look inside to see how it's made. A SECTIONAL VIEW allows you to look inside an object shown on a blueprint. One of the views is shown just as if you had sawed out a section.

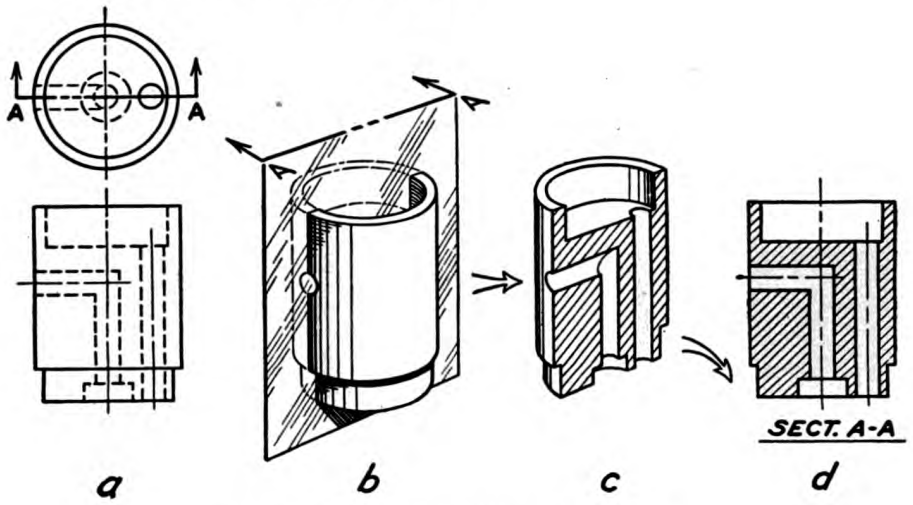


Figure 14.—Action of the cutting plane.

Notice the CUTTING PLANE LINE *AA* in figure 14*a*. It shows where the imaginary cut has been made. The isometric in figure 14*b* helps you to visualize the cutting plane. The arrows point in the direction in which you are to look at the sectional view.

Figure 14*c* is an isometric showing how you would see the object if it were actually cut in two.

The orthographic view of section *A-A*, figure 14*d*, is placed on the drawing instead of the confusing front view in figure 14*a*. Notice how much easier it is to understand.

When sectional views are made, the part that is cut by the cutting plane is marked with diagonal, parallel SECTION LINES. The draftsman calls the process of making these lines CROSSHATCHING. When two or more parts are shown on one view, each part is sectioned or crosshatched with a different slant of line.

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Section views are necessary for a clear understanding of complicated parts. On simple drawings a section may serve the purpose of an additional view.

Section *A-A* in figure 14*d* is in FULL SECTION, because the object is cut completely through. You won't always see a full section. There are other sections that help you to LOOK INSIDE.

OFFSET SECTION

In an OFFSET SECTION you have a joggle or offset in the cutting plane. The offset cutting plane in figure 15 is arranged so that the hole on the right side will

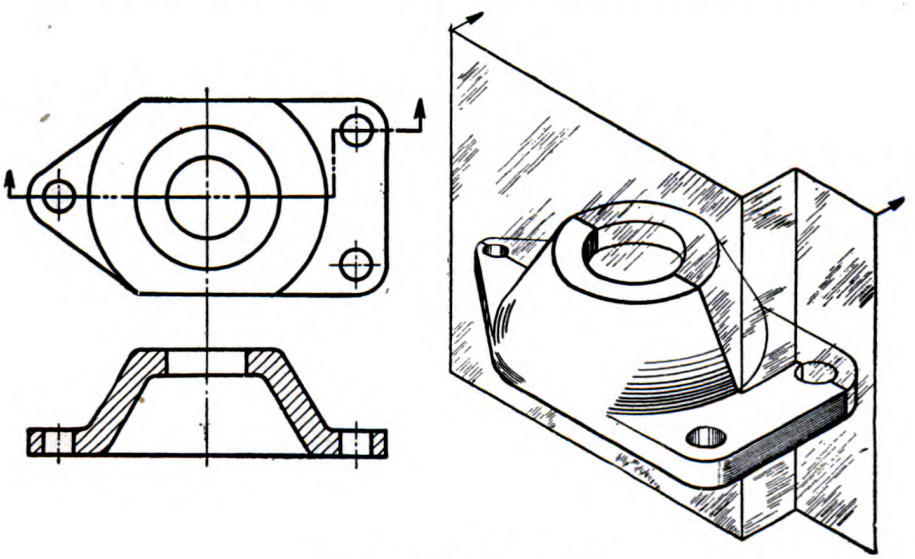


Figure 15.—Offset section.

be shown in section. The sectional view is the front view, and the top view shows the offset cutting plane line.

HALF SECTION

Two cutting planes meet at right angles at the centerline to show a HALF SECTION. In the front view, figure 16, the left half is a half section and the right half is plain orthographic, without hidden lines. The draftsman has placed an arrow to show your line of sight.

Think of a pie with one quarter removed and your

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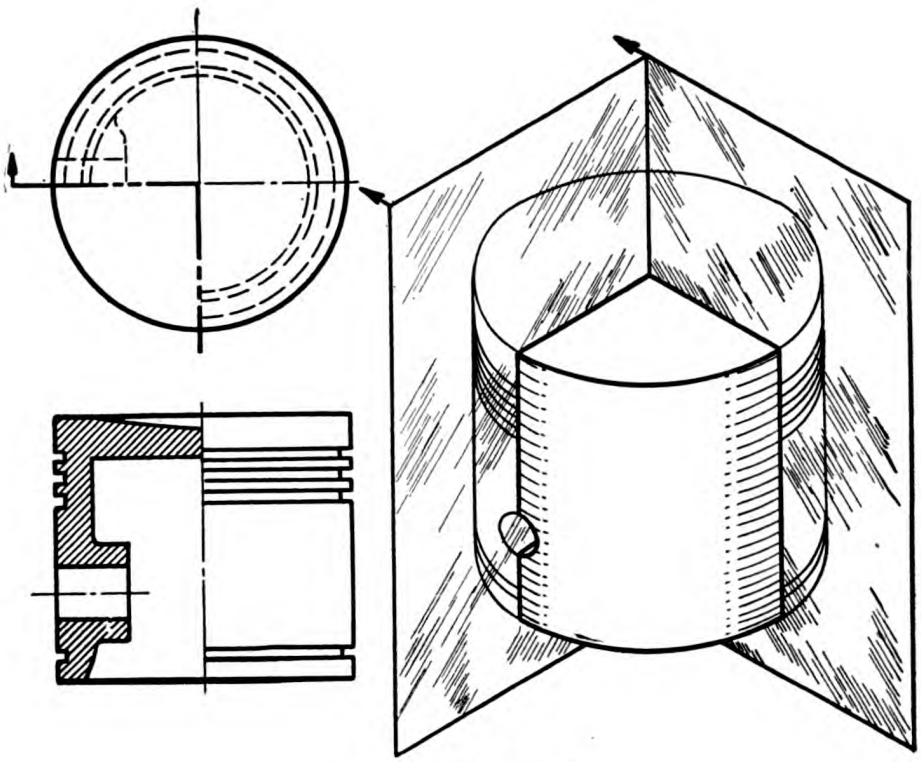


Figure 16.—Half section.

line of sight directed at one of the cut surfaces. That's your half section.

REVOLVED SECTION

To eliminate drawing extra views of rolled shapes, ribs, and similar forms, the draftsman uses a REVOLVED SECTION. It is really a drawing within a drawing. It clearly describes the object's shape at a certain cross-section station or point.

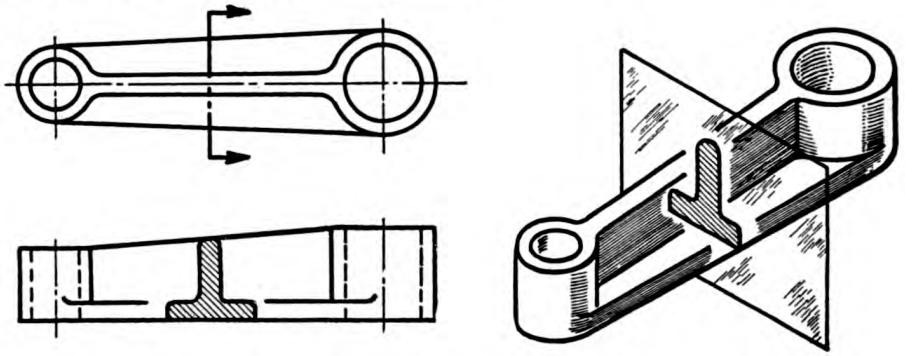


Figure 17.—Revolved section.

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The draftsman has revolved the sectional view of the rib, figure 17, so you can look at it head on. Because of this revolving feature this kind of section is called a revolved section.

BROKEN-OUT SECTION

The inner structure of a small area may be shown by peeling back or removing the outside surface. The

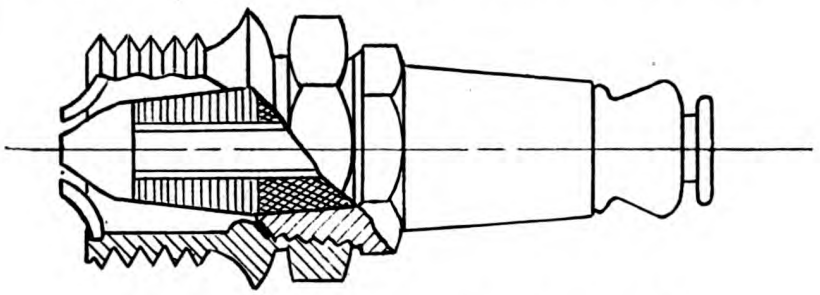


Figure 18.—Broken-out section of a spark plug.

spark plug interior is better shown in figure 18 because of the BROKEN-OUT SECTION. You can look right inside.

ALINED SECTION

Look at the front view of the handwheel in figure

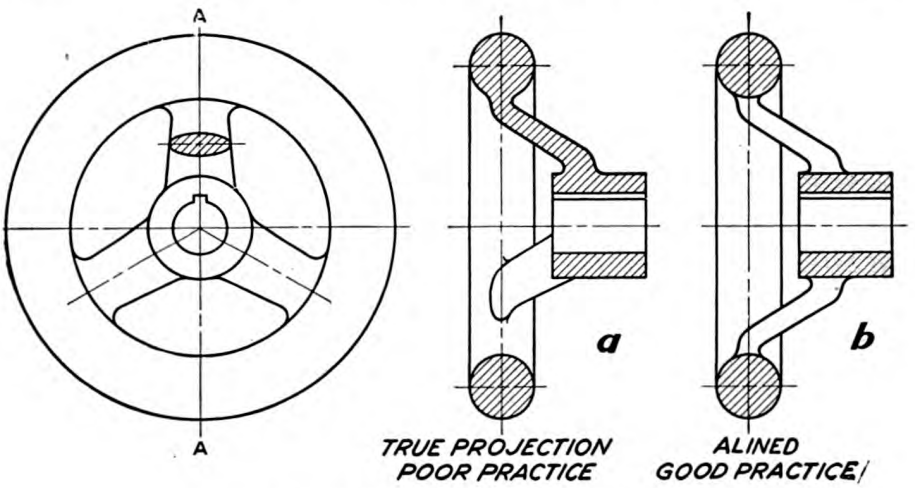


Figure 19.—Alined section of a handwheel.

19. Notice the cutting plane line *AA*. The TRUE PROJECTION section is shown at *a*. Confusing, isn't it?

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The draftsman clears up this confusion with an ALINED SECTION.

By revolving one of the other spokes to a position on the cutting plane line of the front view, the draftsman clears up the confusion. Notice that the spokes are not cross-hatched in the alined section. That's the usual way of indicating that IT IS an alined section.

CONVENTIONAL BREAKS

A long bar or pipe that has a uniform cross-section is not always shown in its entire length. By breaking

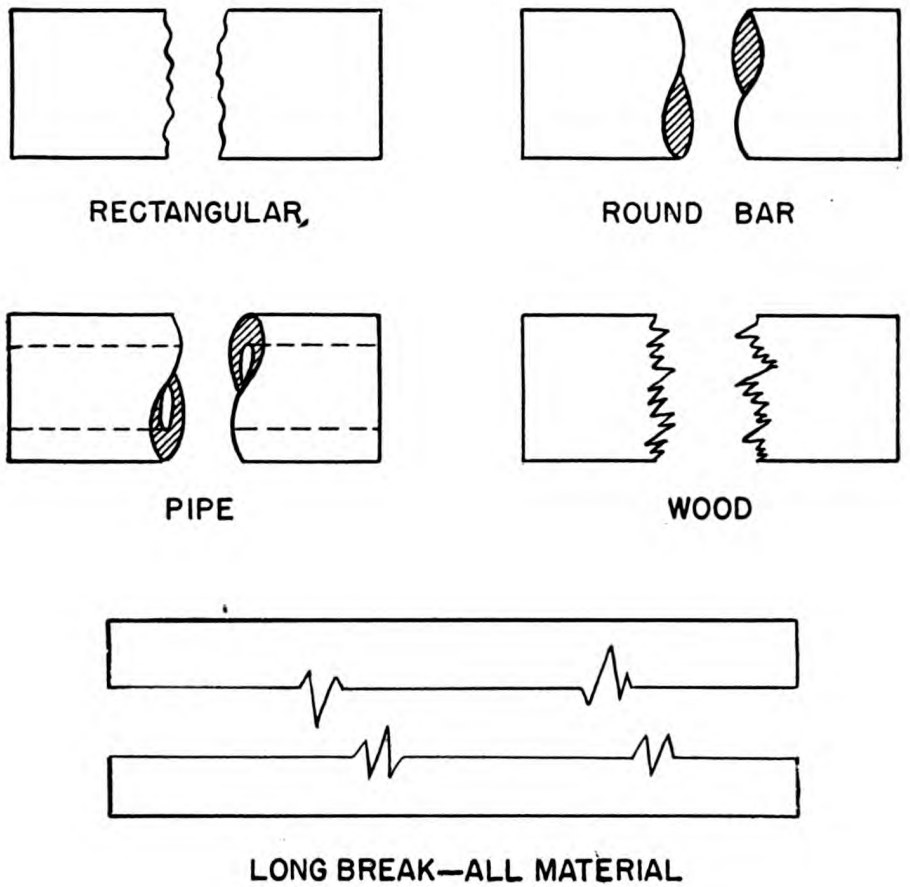


Figure 20.—Conventional breaks.

out one or more pieces and moving the ends together, the drawing can be made smaller or the views larger.

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The true length is indicated by a dimension so you can use the view just as well as if it were not broken.

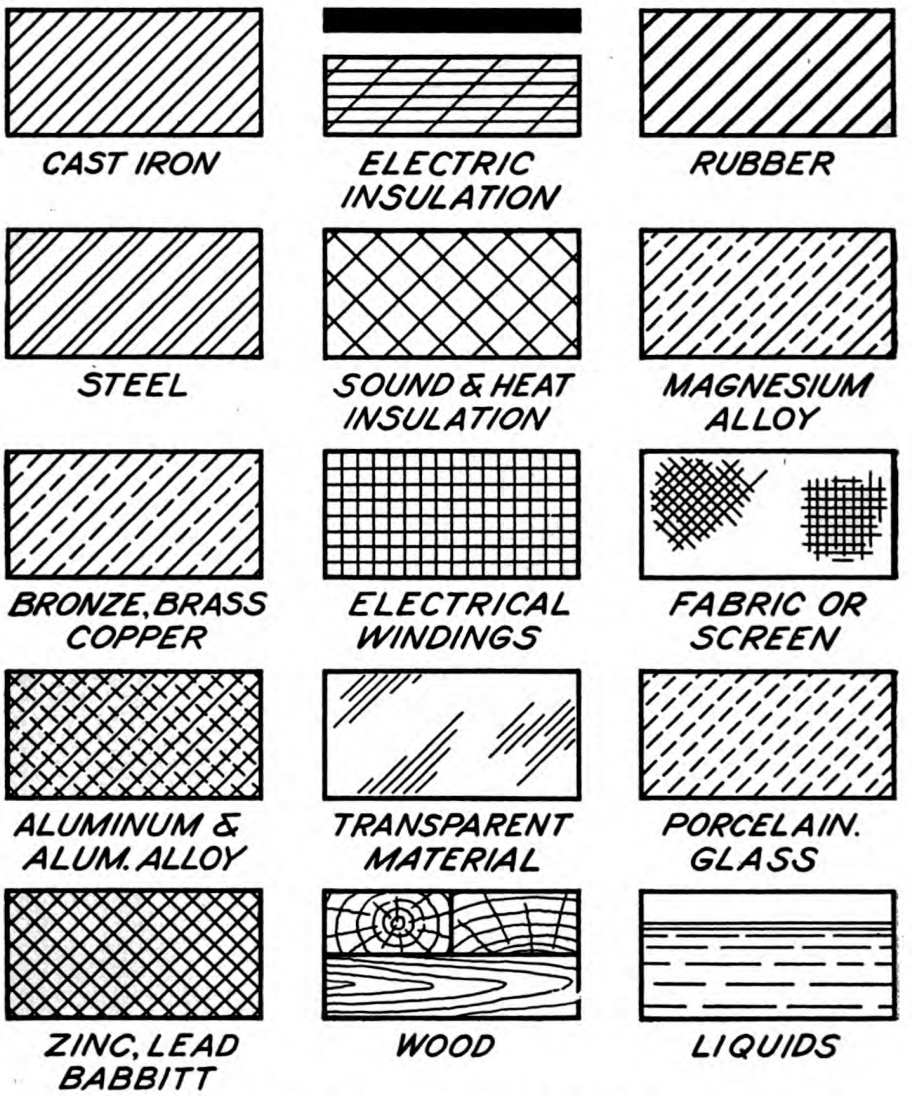


Figure 21.—Section lining symbols.

Many kinds of breaks are used to show different shapes and materials. Some of the commonly used breaks are shown in figure 20. Often you will find a revolved section placed in the break.

MATERIAL SYMBOLS FOR SECTIONS

The sectional view may be lined or crosshatched with a special line arrangement to indicate KIND OF

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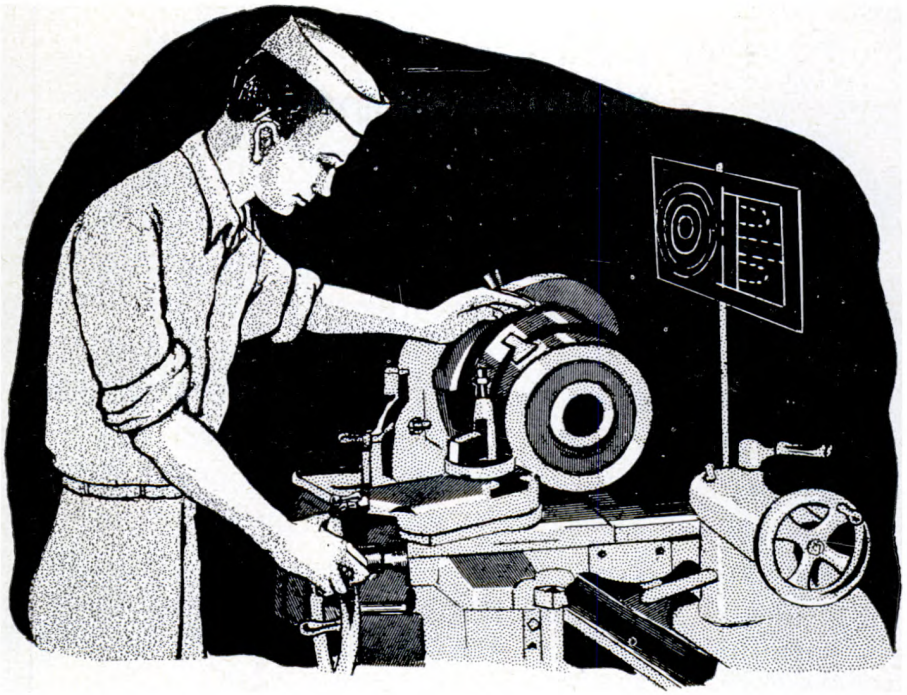
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MATERIAL. The symbols shown in figure 21, are intended for general information. They do not indicate specific types. For example, the symbol for steel doesn't indicate whether it's tool steel, cold-rolled, tungsten, or some other type of steel. The particular type will be indicated somewhere else on the print.

Sometimes, to simplify the drawing, the cast iron symbol is used for all metals—except lead and babbit.

You may bump into some special symbols. Color may be used. In a hydraulic system of a gun mount, the flow of the hydraulic liquid may be shown by colors. Special symbols will be explained in the BLUEPRINT LEGEND. This legend is a sort of table that furnishes information difficult to show on the views of the drawing.

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CHAPTER 4

THE WORKING DRAWING TELLS EVERYTHING

DIMENSIONS

You'll find plenty of information on a WORKING DRAWING blueprint. It has everything—ALL the information you need to MAKE the object. Much of this vital information is shown by dimensions. You've been introduced to them—now you're really going to get acquainted.

The accuracy of any work you do with blueprints depends on ACCURATE READING of the dimensions. You need to know how dimensions are selected and arranged and some methods of using them for layout work.

When you're shooting goals on a basketball court, ACCURACY is all-important. The ideal shot splits the net without touching the rim. The basketball is somewhat smaller than the loop so you have some leeway in making the basket.

Blueprints also provide for leeway in hitting the

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basket. The leeway is applied to the dimensions and is known as tolerance, limits, and allowance.

DEGREE OF ACCURACY

Know what you're doing. If you fail to follow the dimensions on a blueprint, the part you either make or repair may fail in service. It may break down at just the wrong time and endanger the lives of your shipmates. When you make it, MAKE IT RIGHT by following the road signs of blueprints—dimensions.

An error of 5/1000 inch can be as destructive as an error of 1/4 inch. In fact, the small error may be more dangerous because it is not so easily detected as the large error. If the dimension calls for a piece 3 inches long, it means the piece should be made as near 3 inches as you can make it with the available tools. But—

ABSOLUTE ACCURACY IS IMPOSSIBLE. Even the 6-inch rule with which you measure is not absolutely accurate. Temperature alone can make a liar out of it. Cold may cause it to be slightly less than 6 inches and heat may make it slightly more than 6 inches.

Engineers realize that absolute accuracy is humanly impossible so they figure how much variation is permissible. This leeway is stated on the drawing as ± a certain amount, as ±1/8 ± 1/64 or ±0.005.

LIMITS AND TOLERANCE

The dimension on a blueprint represents the perfect size and is known as the BASIC DIMENSION. In figure 22 it is 3.0 inches. The LIMIT of error allowed is ±1/8 inch. The minimum length is 2 7/8, the maximum length 3 1/8.

Don't expect to have that much leeway on most work. Woodworking usually requires a limit of ±1/32 inch, sheet metal work ±1/64 inch, and machine parts ±.005 inch or less. Many fine mechanisms have limits of error of ±.0001 inch. You can

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trust your eyes to measure 1/64 with a rule but for closer work use a micrometer or special gage.

The difference between the allowable minimum and maximum dimensions (short limit and long limit) is known as the TOLERANCE. In figure 22 it is ¼ inch.

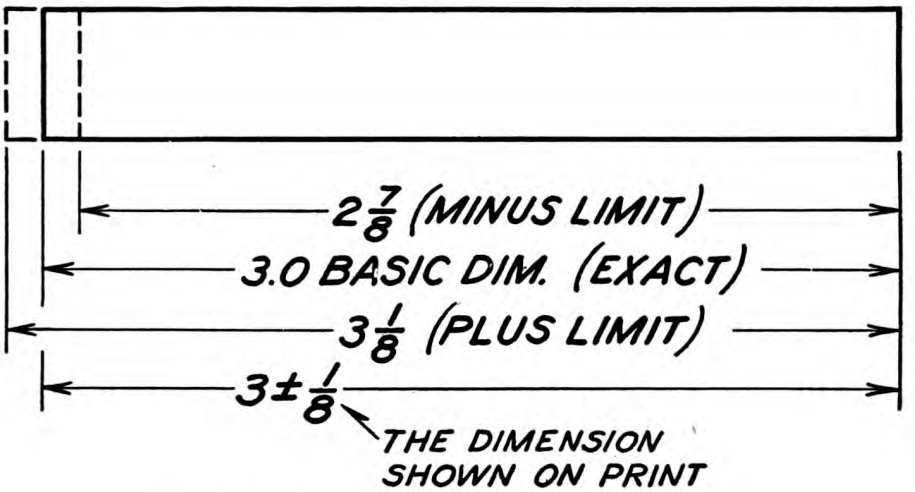


Figure 22.—Basic dimension, limits and tolerances.

Here's another example to show you how the system works.

Basic dimension 2½
Limits±1/64
Long limit 2-33/64
Short limit 2-31/64
Tolerance 2/64 or 1/32

These limits will be stated in either common fractions or decimal fractions. They are found in the title block or legend. Angle limits are stated in terms of degrees, as ±½°.

When you're working with limits, try to hit the basic dimension RIGHT ON THE NOSE. That will help you to stay inside the allowable limits.

ALLOWANCE

A shaft so large that it must be driven into a bearing won't rotate in that bearing. Some CLEARANCE for turning and lubrication is necessary between two moving parts.

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A tight fit, known as a DRIVING FIT or HEAVY FORCE FIT is used to make a permanent assembly. This requires the shaft to have a greater diameter than the hole.

The fits of shafts and holes have been standardized into eight classes, numbered from 1 to 8.

CLASS 1 allows plenty of clearance and is used for fast moving machine parts of large size.

CLASS 2 is a slightly closer fit and is used for engines, dynamos, and machine tool parts.

CLASS 3 is a snug fit with a very small clearance and is used for extremely accurate, slow-moving parts.

CLASS 4 has no clearance and is the nearest thing to a perfect fit.

CLASSES 5 to 8 allow for the shaft to be increasingly larger than the hole and are used where the shaft does not rotate in the hole.

Remember that allowance is the difference in size of mating parts, necessary for their proper operation. Keep in mind that the larger the CLASS number, the TIGHTER the fit.

The allowance for a RUNNING FIT is known as CLEARANCE and is said to be "positive," because the hole diameter is greater than the shaft diameter. For FORCE FITS, class 5, 6, 7, and 8, this allowance is "negative" and the difference allowed is known as INTERFERENCE. The minimum allowable interference is specified by the dimensions given on the blueprint.

BASIC HOLE ALLOWANCE SYSTEM

The BASIC HOLE SYSTEM is a standard method of determining the size of a hole into which a shaft is to be fitted.

The HOLE can be LARGER than the basic dimension, but not smaller. The hole limits are plus only. It's known as a PLUS TOLERANCE.

The SHAFT has a MINUS TOLERANCE only. It can be SMALLER than the basic dimension.

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Look at figure 23. It's a part of a blueprint showing a shaft and a hole. Can you read it?

The minimum or basic diameter of the hole is 2.500 inches. For a CLASS 1 fit, the allowance is positive and for a hole this size is 0.005 inch. This means that the shaft CANNOT be larger than 2.495 or the hole

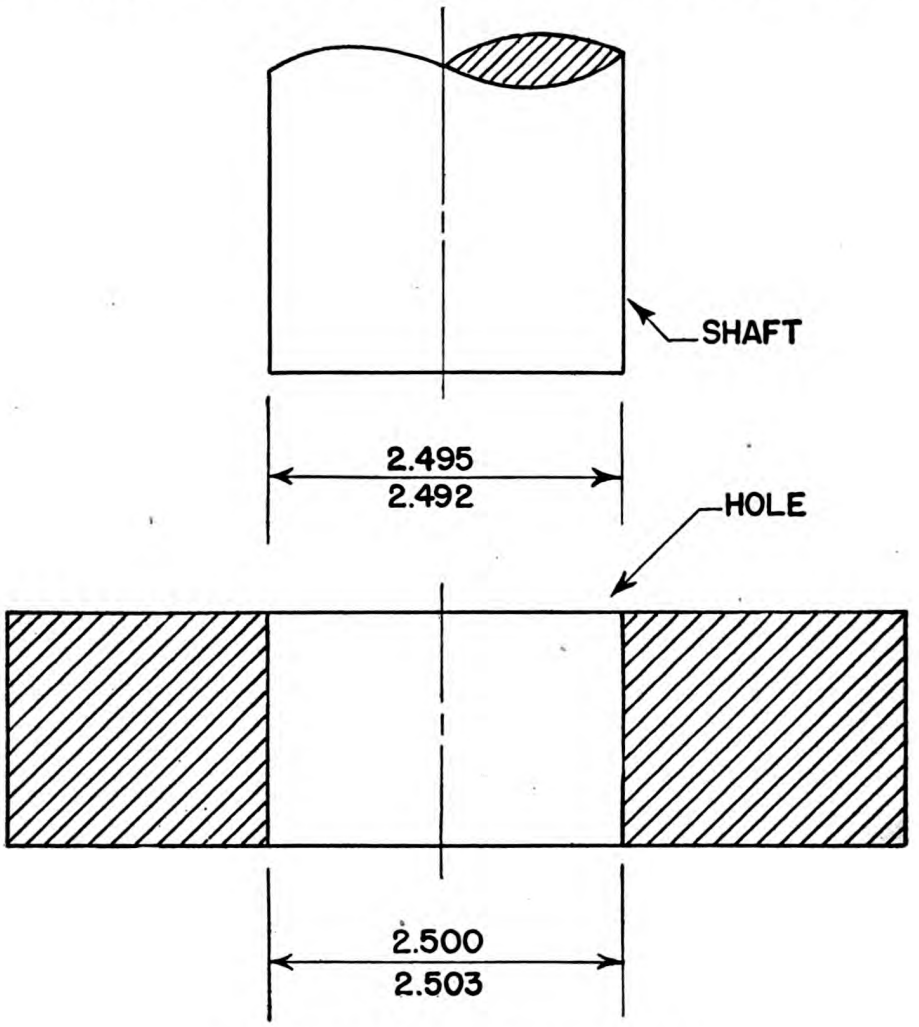


Figure 23.—Basic hole allowance system.

smaller than 2.500. There must be AT LEAST .005 clearance.

The limits for a hole this size are given as ±.003. The hole can be as large as 2.503—but NO LARGER. The shaft can be as small as 2.492 but NO SMALLER. The total allowable variation, in this particular case,

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is .011. The fit must have a clearance of from .005 to .011 inch.

DIMENSIONS AT WORK

How will you use limits, tolerances, and allowances? There are two ways, for SIZE and for LOCATION.

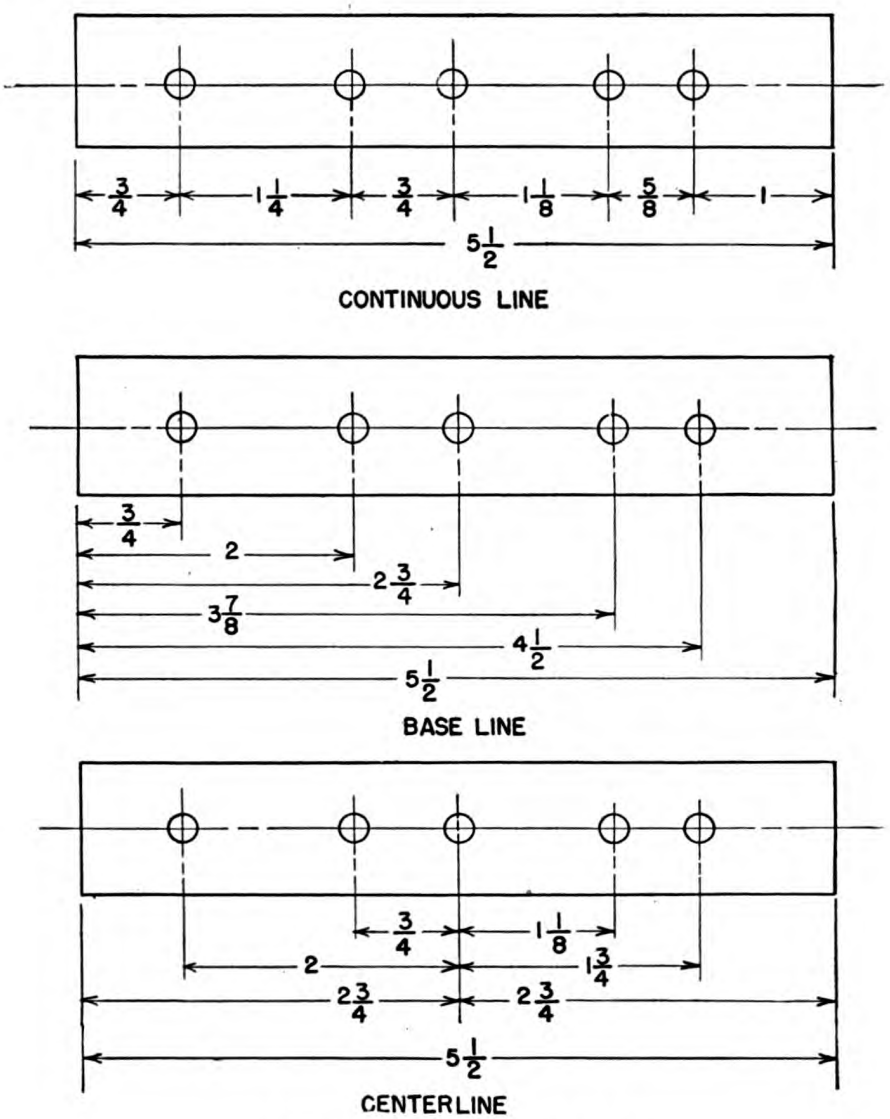


Figure 24.—Dimensions at work.

When you work a piece of steel to the proper shape you'll follow the SIZE DIMENSIONS. They will tell you length, width, thickness, and depth.

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When you locate a hole or a slot you're following LOCATION DIMENSIONS.

There are many methods that draftsmen use to place dimensions on the drawing. Three methods are shown in figure 24. You may run into variations of these three methods, because the draftsman indicates where the greatest degree of accuracy is expected by the manner in which he places the dimensions.

CONTINUOUS DIMENSIONS

For small parts that do not require many dimensions, the CONTINUOUS LINE system may be used. It's accurate, IF used properly, but you must avoid having ACCUMULATIVE ERRORS.

What would be the result if you measured an 800 foot battlewagon with a six inch rule? You would make 1,600 measurements. An error of 1/64 inch on each measurement might give you an overall error of 25 inches. It's not accurate enough. You could do a lot better with a six foot rule or a 50 foot tapeline. So don't measure from station to station.

To make an accurate layout from continuous line dimensions, select a BASE POINT and measure from that ONE POINT. Use this method and you can have only ONE SMALL ERROR for each dimension. When you do make a mistake it affects only ONE LOCATION or DIMENSION. Always use the base point method, even if dimensions are in a continuous line as shown in top of figure 24.

BASE LINE DIMENSIONS

You'll find it easier to avoid those ACCUMULATIVE ERRORS when you use base-line dimensions. This method, shown in center of figure 24, is used where OUTLINE accuracy is important.

Notice that all measurements are taken from ONE BASE LINE. The principal disadvantage of this system is that it requires a lot of space.

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CENTERLINE DIMENSIONS

The centerline system, shown in bottom of figure 24, is used primarily for exact hole location. It is used when the holes in one piece must exactly fit in line with holes of another piece. The centerline system provides a BASE POINT from which all measurements are taken to locate other points. When using this system, be sure to make ALL MEASUREMENTS from this ONE BASE POINT.

HOW THREADS ARE DRAWN

You have heard a lot about SECURITY in the Navy. Parts of machines, engines, and boats must be secured to each other. Many metal parts and pieces are secured to each other with THREADS AND THREADED FITTINGS.

There are various ways of representing threads. OUTSIDE THREADS are shown in figure 25.

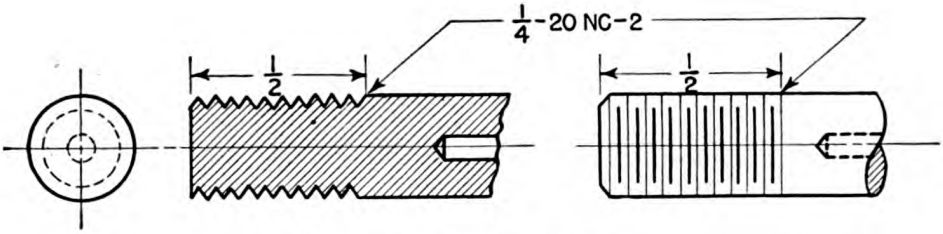


Figure 25.—Outside threads.

On the left you see a thread profile in section. On the right is a common method of showing threads. The draftsman would waste a lot of time if he drew the threads exactly as they look, so he uses symbols. The symbols are not drawn to scale. The length of the threaded part is dimensioned but other necessary information appears in the NOTE.

The first number of the note, 1/4, indicates the outside diameter of the thread. The number after the first dash, 20, shows that there are 20 thread points per inch. The letters, N.C., indicate a type of thread, National Coarse.

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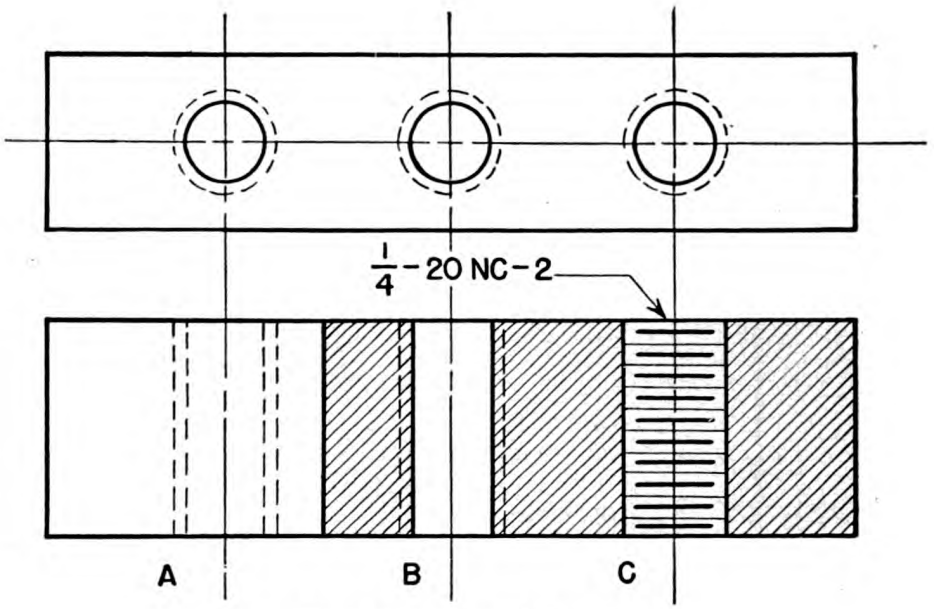


Figure 26.—Internal threads.

The last number, *2*, indicates a No. *2* thread fit, which is a free fit. This shows what a lot of "dope" you can place on a blueprint with one small note.

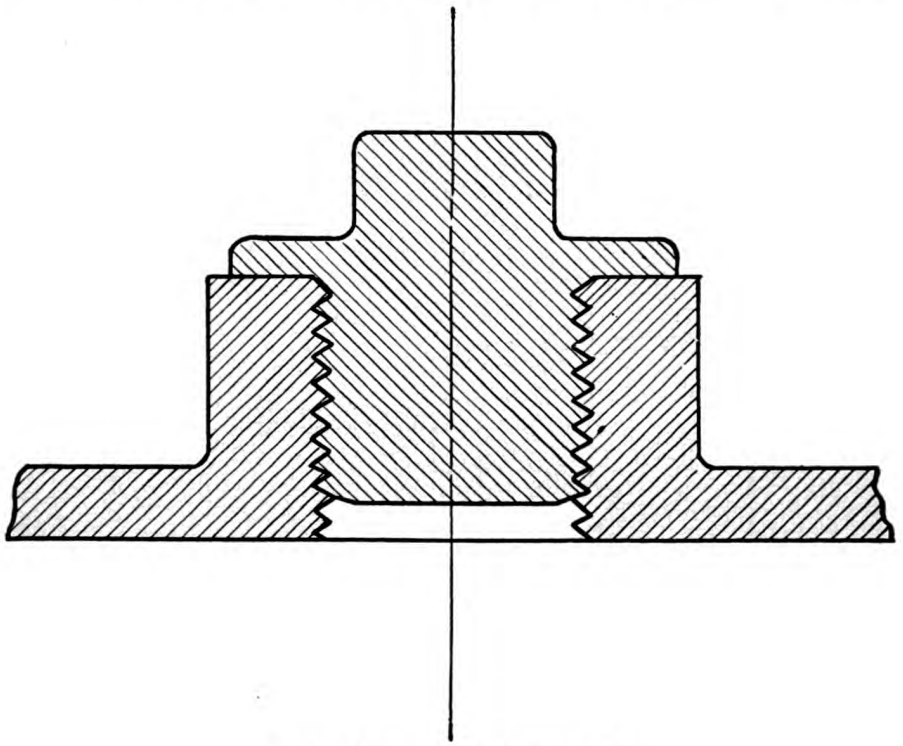


Figure 27.—Threaded assembly.

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INTERNAL THREADS, figure 26, may be shown by several kinds of symbols. Here again it's too much trouble to draw the threads accurately when an easily drawn symbol will do the job just as well.

Notice that the threads in figure 25 may be screwed into the threaded holes in figure 26. WHY? Because the NOTE on each one tells us that the threads are exactly the same.

Sometimes threads may be shown IN SECTION, especially in assembly views. Notice figure 27. It shows clearly the relationship of the plug and the opening into which it is screwed.

BOLTS and STUDS are shown on drawings by outlines and symbols, as in figure 28.

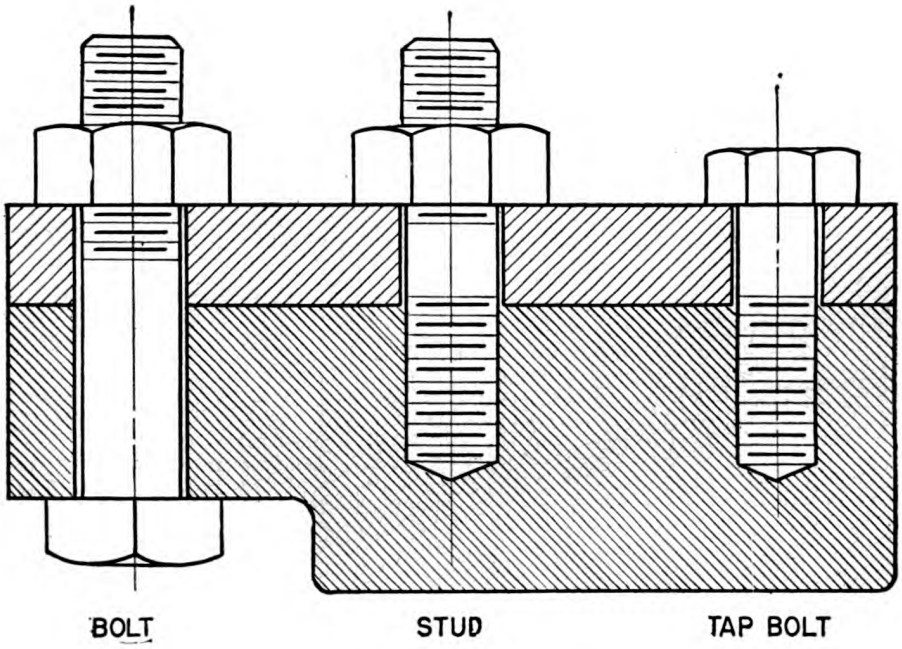


Figure 28.—Bolts and studs.

Such items as set screws, bolts, cap screws, wood screws, and rivets are represented so clearly that you will have no trouble recognizing them. The important thing is to learn the THREAD SYMBOLS. Get them and you're all set.

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SPECIAL SYMBOLS

These SPECIAL SYMBOLS, figure 29, may be found on some blueprints.

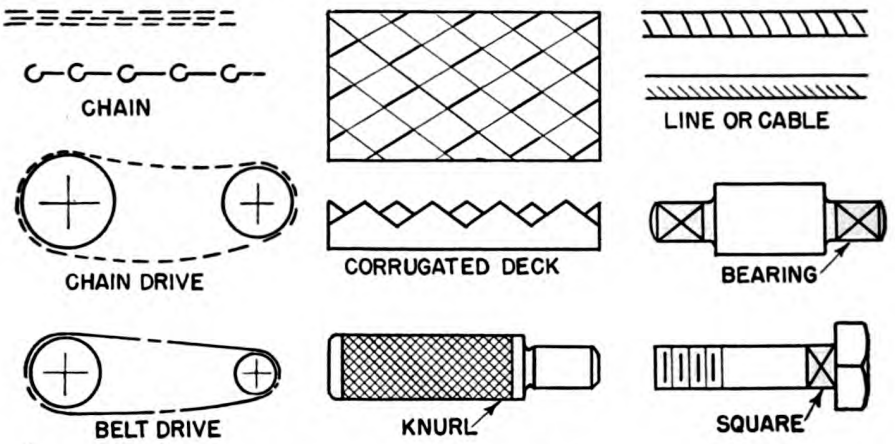


Figure 29.—Special symbols.

You're going to find YOUR RATE will have other SPECIAL SYMBOLS used especially by that rate. It's up to you to learn the ones applicable to YOUR RATE.

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CHAPTER 5

READ IT YOURSELF

ALL-IN-ONE

A blueprint is the neatest all-in-one job that ever happened!

From the information on just one sheet of paper you can visualize SIZE, SHAPE and STRUCTURE. From the blueprint you can make anything properly planned by the designer.

Once you get a blueprint in your hands you have only two things to do—READ and MAKE.

Scout around and get a blueprint to refer to as you read. Get one that shows ONLY ONE PART of a gun, engine, or machine. It's a DETAIL DRAWING if it shows only one part and that's what it takes to make something. Follow your drawing as you read this chapter.

A detail drawing has been inserted in this chapter for you to follow if you're unable to obtain one to use.

Take a good look at the blueprint you have. How are you going to use it? You can think of plenty of questions to ask—DON'T ASK THEM. Find the answers for yourself. They're all on the print—the draftsman didn't leave out ANYTHING. The drawing has been checked and re-checked.

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Just USE YOUR HEAD and you'll be surprised how easy it is for you to pick the information from the print. If you REALLY do get stuck, ask some rated man in your division to bear a hand and help you get squared away.

You're acquainted with the lines, symbols, dimensions and notes—they're old friends. It's the strangers you're going to meet now.

What do you see first when you pick up a newspaper? THE HEADLINES. Now look at the headlines on your drawing.

THE TITLE BLOCK

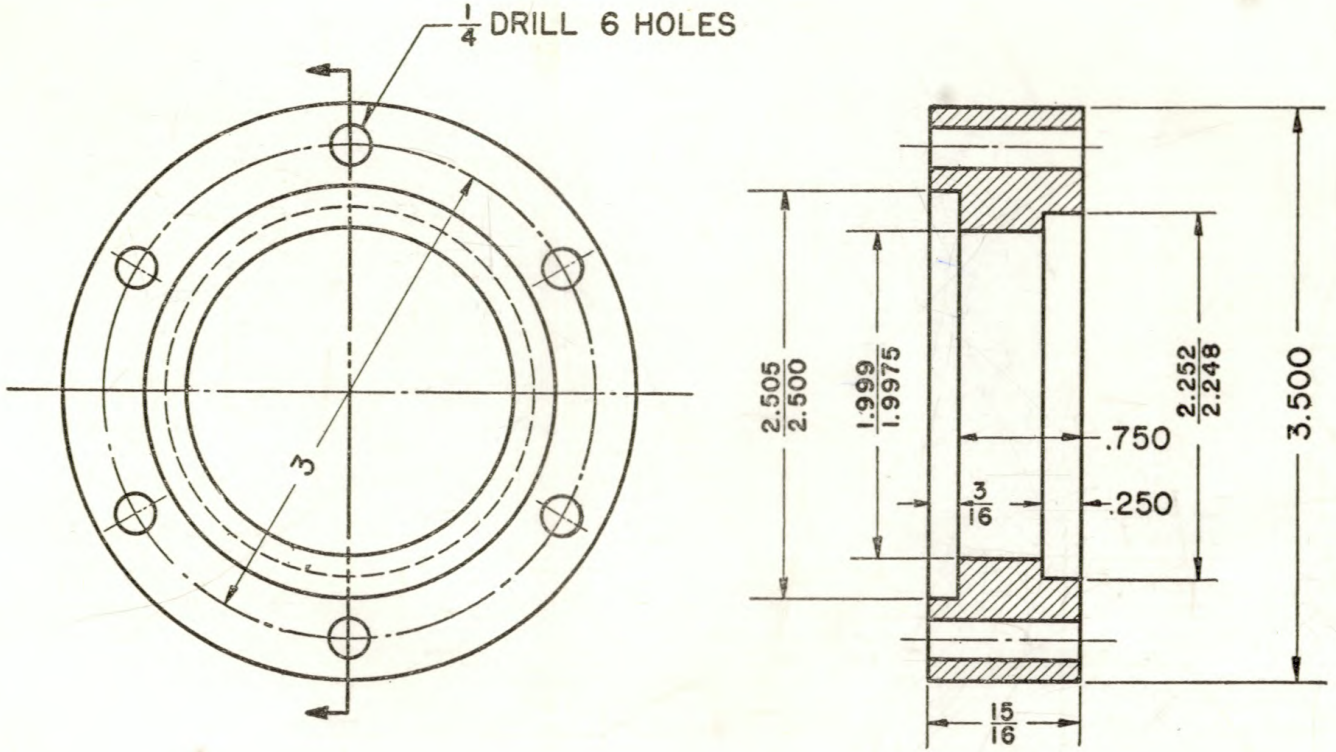
The headlines on the blueprint are in the TITLE BLOCK or box. It's divided into spaces and each space contains special information for you to use. If a space has a diagonal or slant line drawn across it, disregard that space on your title block. The diagonal line indicates that the information usually placed in that space is not required on your drawing.

The title block usually appears in the lower right corner of the print. Don't get excited if it's somewhere else. It may be placed anywhere around the borderline of the drawing.

The first headline to look for in the title block is the NAME OF THE PART. Look for it in the largest space, printed in large letters. Notice how it's written—much the same as your name appears on the watch list. Take a look at the name of the part in the title block in figure 30. The actual name of the part comes FIRST and descriptive words follow. It's the same principle of identification the Navy uses when it asks you to fill out a form with your last name first.

Near the name of the part you'll see the part number. This same number is CAST, STAMPED or STENCILED on the part if space permits. The part number is the DOG-TAG for that part. It simplifies IDENTIFICATION and REPLACEMENT, when one assembly has many parts.

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LIMITS	6	SAE 1040	MACHINE	77-G	STOCK SIZE 1×3 3/4×3 3/4
FRACTIONAL ±1/64 DECIMAL ±.005 ANGULAR ±1/2°	NO. REQ'D	MATERIAL	FINISH	PATT. NO.	
	SLIDE BUFFER CLAMP SCALE: 3/4 = 1				136343-36
CAUTION: DO NOT SCALE	DRAWN:	CHECKED:	TRACED:	APPROVED:	HEAT TREAT / REFER TO
	C.R. SWARTZ	B.C. DOYLE	M.R. MEIGS	C.C. CLINGER	

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STOCK SIZE 1×3 3/4×3 3/4	77-G	MACHINE	SAE 1040	6	LIMITS
	PATT. NO.	FINISH	MATERIAL	NO. REQ'D	FRACTIONAL ±1/64 DECIMAL ±.005 ANGULAR ±1/2°
136343-36	SLIDE BUFFER CLAMP SCALE 3/4=1				
	APPROVED:	TRACED:	CHECKED:	DRAWN:	CAUTION: DO NOT SCALE
REFER TO	HEAT TREAT	C.C. GLINDER	M.R. MEIGS	B.C. DOYLE	

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When a new part is ordered from the manufacturer, he will want to know the assembly, name of the part, and its number.

Part numbers are standardized by the manufacturer and by the Navy. For example, an ordnance drawing has two numbers with a dash in between. The first number is the DRAWING NUMBER and the number after the dash is the PART NUMBER, as 103465-26.

If a change is made, or the drawing revised, a letter is added to indicate the change, such as 103465-26-A. The same letter is indicated on the drawing at the point where the change was made.

Often a separate table is provided on the drawing to record the letter of the change, the change itself, date of change, and initials of the person making the change. This information may be included in the title block on some drawings.

Now take another good look at the part number in figure 30. Does the title block of your drawing have a part number?

LIMITS ON DIMENSIONS UNLESS OTHERWISE SPECIFIED ANGULAR $\pm\frac{1}{2}$ FRACTIONAL $\pm\frac{1}{32}$ DECIMAL $\pm$.010	CAST STEEL MATERIAL		NOTED ON DRAWING MATERIAL SPEC.
	13.65 WEIGHT		MILL SLOTS MACHINE FINISH
	HEAT TREAT	2 NO. REQ'D.	IN PLACE OF
CAUTION DO NOT SCALE DRAWING WORK TO DIMENSIONS	ZINC CHROMATE FINISH	1" = 2" SCALE USED	STANDBY POWER UNIT MARK III-MOD. I ASSEMBLY
BRACKET GENERATOR MOUNT NAME OF PART			103465-26 PART NUMBER
LBC	RBD	C.R.S.	H.B.K.
DRAWN BY	CHECKED BY	LAYOUT BY	APPROVED BY

Figure 30.—Blueprint title block.

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SCALE

The SCALE of the drawing is indicated in one space of the title block. It indicates the SIZE OF THE DRAWING as compared with the SIZE OF THE PART. The scale is usually stated as 1″ = 2″, 1″ = 12″, etc. It may be indicated as FULL SIZE, ONE-HALF SIZE, ONE-FOURTH SIZE, etc.

When the draftsman uses a scale of 1″ = 2″, the object is shown half as large as its actual size. For a scale of 3″ = 1″ the object or part is drawn three times its actual size.

Very small parts are enlarged and large objects are reduced in size to show the views clearly. The scale is selected to fit the object being drawn and the space available on the sheet.

CAUTION—DANGER AHEAD

When you drive a car over winding roads you see a lot of caution signs. They help you to PREVENT ERRORS or ACCIDENTS. Notice the caution sign in figure 30. The draftsman is telling you NOT TO SCALE OR MEASURE the drawing. He tells you to work to the dimensions. The dimensions are correct but the lines on the drawing may not be absolutely accurate.

NEVER MEASURE A DRAWING. USE THE DIMENSIONS.

MATERIAL

You may be able to visualize a part, read and use dimensions, understand notes and symbols, but you're STUCK unless you know WHAT MATERIAL to use.

You won't just grab the first piece of STOCK or material you find. Use the material specified in the title block. Rely on these materials and on their SPECIFICATIONS—SPECS to you. Never make a substitution unless you have the proper authorization.

That material indicated in the title block was selected by an engineer because it met the requirements of the job. It's the best material for that particular

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job. The more YOU know about the characteristics and qualities of materials the better you can do YOUR work.

LEARN ALL YOU CAN ABOUT MATERIALS. Why is ash wood used for oars? Why is 18-8 stainless steel used for galley fixtures? Why is brass used for steam fittings? What is galvanized iron? These are very simple questions about materials. Can you answer them? Learn all you can about the materials you are using or will use. When reference material is not available ask the rated men in your division.

HEAT TREATMENT

One space of the title block, figure 30, is labeled HEAT TREAT. This refers only to metals and especially to iron and steel.

Metals have characteristics of HARDNESS, TOUGHNESS, DURABILITY, STRENGTH, ELASTICITY, DUCTILITY and MALLEABILITY. Heat treatment includes a number of methods used to change or modify these characteristics to fit a particular job. You need an understanding of some of these heat treating methods.

ANNEALING softens the metal so you can shape it. It improves the DUCTILITY of the metal so that it will stretch without cracking. It increases the MALLEABILITY so the metal can be hammered and forged to shape.

Metal is HARDENED by a heat treating process. Steel can be made hard by heating it to a certain temperature and then dunking it in water or oil. If the steel needs to be hard and TOUGH you can TEMPER it by another special process carried out at lower temperatures.

CARBURIZING or CASE-HARDENING is a method of making the surface of a metal part extremely hard so that it will resist wear.

NORMALIZING removes internal strains in a metal part that has been cast or formed under pressure. These strains need to be removed because they might cause the part to crack or warp.

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The secret of heat treating is the temperature control necessary for the desired result. If YOU are to work with metals learn all you can about heat treating processes.

FINISHES

An engagement with the enemy may last for a few minutes, hours, or days, but ONE BATTLE goes on FOREVER. It's the battle between the Navy and CORROSION—RUST to you.

Rust is the corrosion of the ferrous metals—iron and steel. Rust is just one form of corrosion. Most metals corrode some—that's why you have to keep polishing them, if they are not protected against corrosion.

Corrosion is caused by the chemical reaction of a metal with the elements—with air or water. You can prevent this corrosive action by sealing the surface of the metal with a PROTECTIVE coating. You can use paint, lacquer, enamel, varnish, oil and grease as protective coatings. The Navy has developed SPECIAL RUST PREVENTATIVES for iron and steel. Learn about them so you can understand what the blueprint means when it specifies a certain finish.

Why does a car bumper stay shiny and bright. Because it's PLATED with a corrosion resistant metal. Many steel parts of ships, engines, and machines are plated to retard corrosion. One of the best plating metals is CHROMIUM. Other plating metals are zinc, copper, brass, and tin.

The SURFACES of large parts may be painted, enameled, lacquered, or plated for protection. Moving parts that contact other parts are greased or oiled with SPECIAL LUBRICANTS.

RED LEAD and ZINC CHROMATE protect metals from corrosion. Often zinc chromate is used as a PRIMER, or first coat, before paint is applied. Zinc chromate is a yellow color and dries rapidly.

Before a rust preventative coating is applied, the

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part must be CLEAN and free from RUST or OTHER CORROSION. It must be free of water, oil, and grease.

RUST can be removed with EMERY CLOTH. But take it easy, brother—remember those limits and tolerances. You don't want to change them by wearing away the surface of the metal.

MACHINING SYMBOLS

Parts that fit with other parts that rotate and slide are carefully machined or finished to dimensions, with small limits and tolerances. To indicate the edges to be finished, the draftsman places a small letter *f* on the line representing the finished edge. A capital letter *V* may be used for the same purpose. The finish or machining symbol is usually referred to as a FINISH MARK. Don't confuse it with paint.

BILL OF MATERIAL

A special box on the drawing may contain a list of the pieces of stock necessary to make a part or an assembly of several parts. It's called a BILL OF MATERIAL and tells the kind of stock, the size and the specifications.

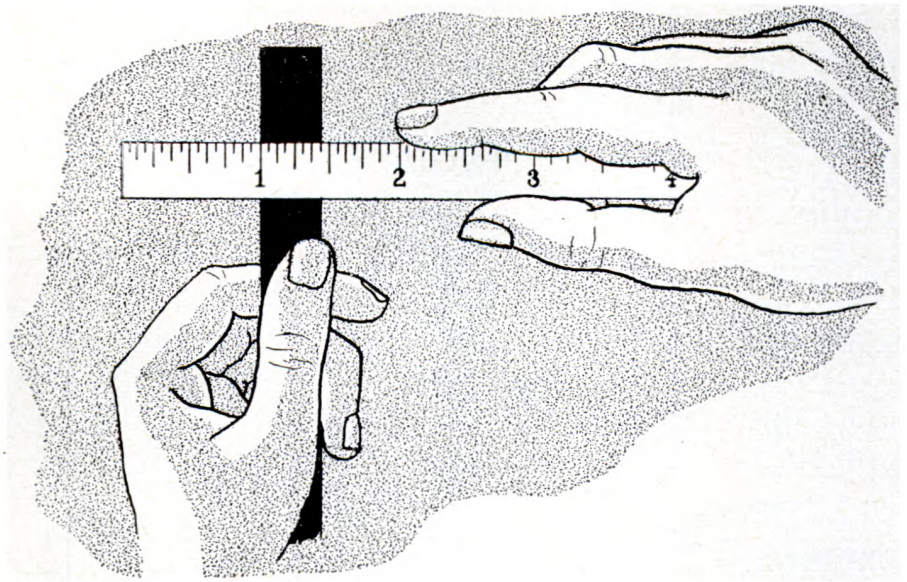
The bill of material for an assembly drawing often has a list of STANDARD parts. Many commonly used items, such as machine bolts, screws, turnbuckles rivets, pipe fittings and valves have been standardized by the Army and Navy. Each item has a number with AN in front of it. A wing nut, for example, has an Army-Navy specification of AN350. A flat-head sheet-metal screw is listed as AN531.

Learn the AN numbers you'll use in your work. It will save you a lot of time and prove that you're up on your toes. You'll find them in the bill of material or on the assembly drawing in the form of notes.

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CHAPTER 6

RULES FOR LAYOUT TOOLS

OFF THE PAPER

Wherever you're stationed, with the fleet or ashore, you'll be expected to know how to do LAYOUT WORK. You'll be MAKING PARTS, REPAIRING PARTS and MAKING AUTHORIZED CHANGES.

Laying out is the METHOD OF PLACING LINES ON THE STOCK to correspond to the lines and dimensions of the blueprint. These layouts are FULL SIZE and must be MEASURED and MARKED ACCURATELY on the stock. Limits and allowances must be observed.

The layout includes object outlines and centerlines. Hidden lines are omitted. Dimensions and notes ARE NOT written on the layout.

To locate, measure, and mark the layout accurately you need to know two things. The first is how to follow a good LAYOUT PROCEDURE STEP-BY-STEP. The second is to know how to USE the best precision LAYOUT TOOLS and keep them in tip-top condition at all times.

Follow the blueprint, learn the procedure, use your

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layout tools properly and you'll have no trouble with layout work. Here's where you learn the tools—procedure is in a later chapter.

PENCILS

You're going to use a pencil for layouts on wood and some sheet metals, such as aluminum and tin plate.

For woodwork you may have a carpenter's FLAT LEAD PENCIL. If one isn't available you can sharpen a common lead pencil to a CHISEL POINT, shown in figure 31.

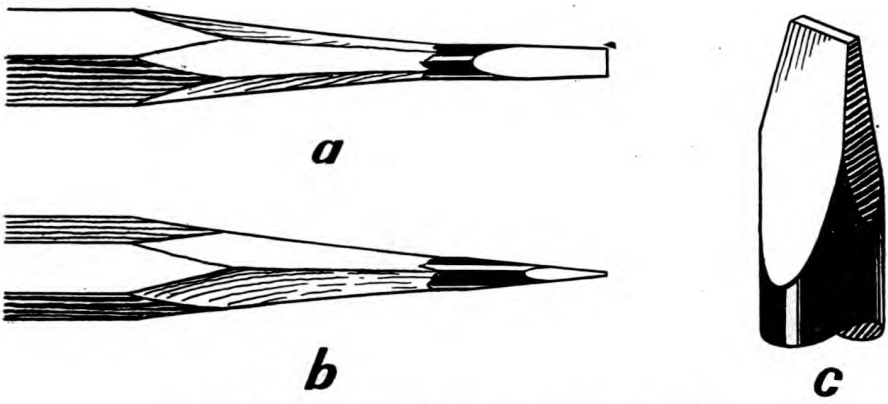


Figure 31.—The correct way to sharpen pencils.

It's OK to use a round-pointed pencil if you have a SHARP POINT that makes a fine, clean-cut mark. The layout lines must be ACCURATE.

The chisel point will stay sharp longer than the round point and won't break so easily.

SCRIBER

A well-sharpened SCRIBER will be used to make CLEAN, NARROW, ACCURATE layout lines on metal. The scriber mark is easy to see and does not rub off or smear. It stays right there so you can USE it when you start drilling, sawing, and filing the metal.

The PLAIN MACHINIST'S SCRIBER is a slender piece of tool steel, tapered to a SHARP POINT at each end. One end may be bent at a right angle for marking lines in tight places. It's a swell SHOP tool but don't

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carry it around in your pocket—it's too dangerous.

If you work away from the shop you can carry a POCKET SCRIBER like the one in figure 32*a*. The marking point of the pocket scriber is removable. You can release the point and place it inside the handle. All scribers have a non-skid grip so they won't slip

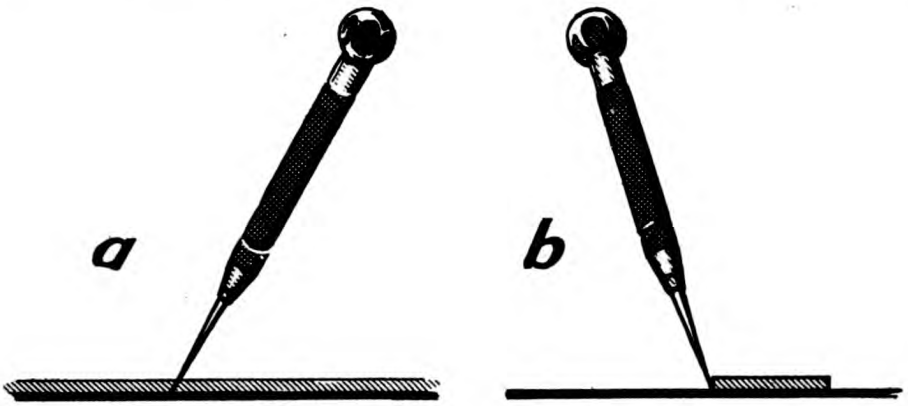


Figure 32.—Using the pocket scriber.

when you're marking the layout lines. The pocket scriber has a KNURLED handle.

Before you use a scriber CHECK THE POINT. Be sure it's round and sharp. To keep the point in good condition, touch it up on an oilstone. Keep revolving it in your hand as you sharpen it. This action will keep the point ROUND.

Now for a few pointers on using the scriber. First of all, hold it firmly—just as you hold a pencil. In figure 32*a* the scriber is shown at an angle with the stock. Hold it in that position when marking along a straightedge. Notice at *b* that the scriber is tilted away from the edge so the point will mark right along the lower edge. Apply even pressure or you'll get a broken and jumpy line.

Make a firm strong line on the first trip. DON'T RETRACE—you may slip off the track and get a BLURRED LINE or a DOUBLE LINE.

No matter how good you are, you'll be OFF a few thousandths with your scribed lines. But if you fol-

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low the rules you can stay well within the prescribed LIMITS OF ACCURACY.

MACHINIST'S STEEL RULE

The stock you mark with scriber or pencil is measured with a RULE. The most accurate type is the MACHINIST'S STEEL RULE. It's a PRECISION INSTRUMENT made of flat spring steel, graduated in inches and parts of inches. The best ones are graduated in eighths and sixteenths on one surface and thirty-seconds and sixty-fourths on the opposite face. Standard lengths

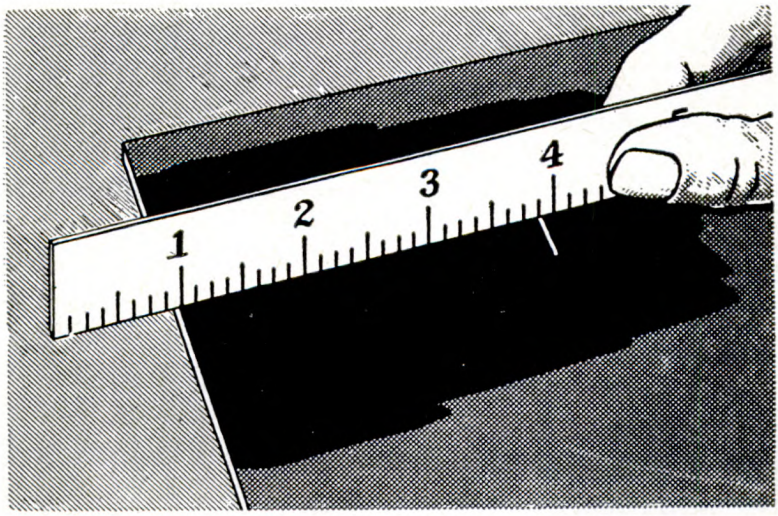


Figure 33.—Using the machinist's steel rule.

are 6 inches and 12 inches but you may find longer rules in your shop.

The graduation marks are about 0.005 inch wide. The perfect measurements are to the CENTERS of those marks. You can't make accurate measurements if the rule is scratched and dented and its marks worn away. Keep a thin film of oil over it, and stow it in a leather case. Don't just toss it in the toolbox with other tools.

There are some tricks of the trade that help you to secure accurate measurements for your layout. Notice that the rule in figure 33 is HELD ON EDGE, so that the graduation marks TOUCH the surface of the stock.

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By holding the rule on edge you can pick the marks right off the rule onto the stock with your sharp scriber.

Notice that the measurement is NOT made from the END of the rule. The ends may wear off, so ALWAYS MEASURE FROM THE ONE INCH MARK. Don't measure from the end.

Be sure you can SEE the marks on the rule and the layout. Move the work and yourself so that you have the best available light.

Clamp the stock in the vise or lay it on the bench. Hold the rule in one hand and the scriber in the other.

When you mark off a dimension or scribe a line, CHECK IT WITH YOUR RULE—not next Tuesday, but IMMEDIATELY. Be sure that mark is RIGHT ON THE DOT before you make another measurement.

You will also use the rule to check the part as you make it. When the part is completed, it will be checked in all possible ways with a rule. This check is to make sure that the part is within the limits specified on the blueprints.

STRAIGHTEDGE

You may use your rule as a guide for scribing straight layout lines. You can also use a STRAIGHTEDGE. It's just like a rule except that it's longer and has no graduation marks. You CAN'T MEASURE with a straightedge.

Keep your straightedges in good condition—no dents and no kinks—and you'll always have a reliable guide for scribing long, straight lines and for checking flat surfaces. Oil it and put it away carefully when it's not in use. KEEP IT STRAIGHT.

DIVIDERS

When you were in school, you used a pencil compass to draw circles on paper. You may remember that the compass often slipped so that the line didn't

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come back to the starting point. This situation won't occur if you use the dividers shown in figure 34. They're PRECISION TOOLS for laying out ARCS and CIRCLES and for CHECKING AND MARKING DISTANCES.

The toolmakers' dividers in figure 34 have a SCREW

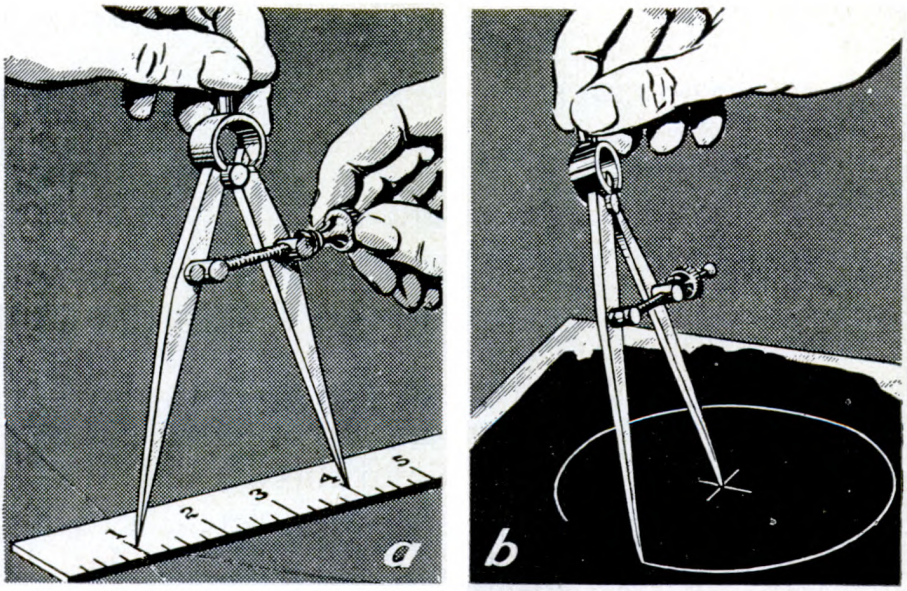


Figure 34.—Setting dividers; swinging an arc.

ADJUSTMENT and can be set accurately. Notice the SETTING METHOD in *a*. The layout man is setting them from the ONE INCH LINE, so the setting will be accurate.

Before the layout man scribes the circle, as in *b*, he will CHECK THE SETTING by marking a circle on a piece of scrap stock and checking the diameter with his rule.

Be sure the POINTS of your dividers are SHARP. When you set them, hold the legs together with one hand while you make the adjustment with the other hand. This system allows the nut to turn easily and prevents unnecessary wear on the screw thread. This method provides an approximate setting and the final setting is made as shown in figure 34*a*.

When the layout man scribes an arc on metal he calls it SWINGING AN ARC. Notice how you hold the

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dividers for swinging the arc—by the handle instead of the legs. If you use a smooth steady swing, and LEAN the marking point in the direction you're swinging, you'll get a well-defined mark with ONE TRIP AROUND. TRACEOVERS mean loss of accuracy and that's bad.

The size of a pair of dividers is the length of one leg. You may have some as small as three inches or as large as twelve inches.

TRAMMEL POINTS

For jobs requiring large arcs and circles, you'll use TRAMMEL POINTS.

Notice how they're used in figure 35. The POINTS or LEGS are attached to a BAR by means of LOCK

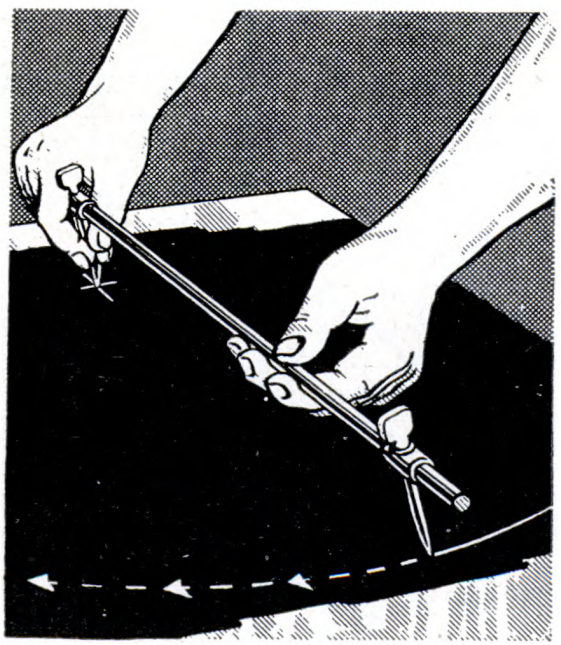


Figure 35.—Trammel points.

SCREWS. When you use the trammel make sure there's no sag in the bar and keep the screws tight—else your radius will WALK AWAY from its intended path. Incline the trammel in the direction of the arc and KEEP THAT ANGLE CONSTANT while swinging the entire arc or circle.

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If you need a trammel and none is available, you can devise a good substitute with a thin wood slat and a couple of sharp nails.

SQUARES

So far you can scribe straight lines and circles. What about ANGLES? SQUARES solve that layout problem.

About 99 percent of the time you'll use squares to make layout lines at right angles (90°) to squared edges. The other 1 percent of the lines will be at angles other than 90°.

For large parts, especially those made of sheetmetal and wood, you'll use the STEEL SQUARE, *A* in figure 36. The common TRY-SQUARE *B* is used where long lines are not required.

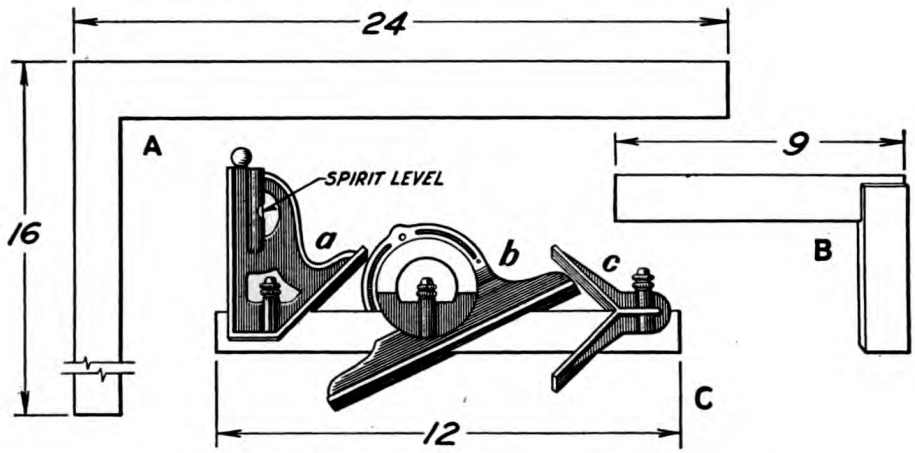


Figure 36.—Steel square, try-square and combination set.

When you need to make extremely accurate layouts you'll reach for your COMBINATION SQUARE SET, *C* in figure 36. You'll cruise a long way without finding a more practical tool for layout work and for checking angles and surfaces.

The combination set has one 10″ or 12″ blade to which three types of head may be fitted.

Head *a*, known as the STOCK, gives you a perfect 90° try-square or a tool for laying out and marking 45° angles. This head contains a SPIRIT LEVEL. It's

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handy for leveling up your work but don't try to use it on a pitching and rolling ship. Figure 37 shows how the square stock and blade may be used.

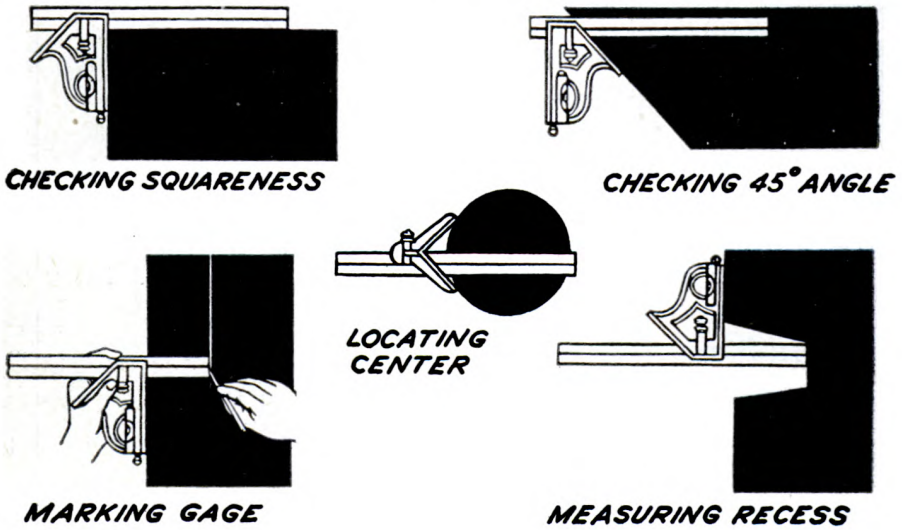


Figure 37.—Some uses of combination square set.

In the center illustration, figure 37, the use of the center head is shown. You'll use it to locate the center of a round bar or shaft.

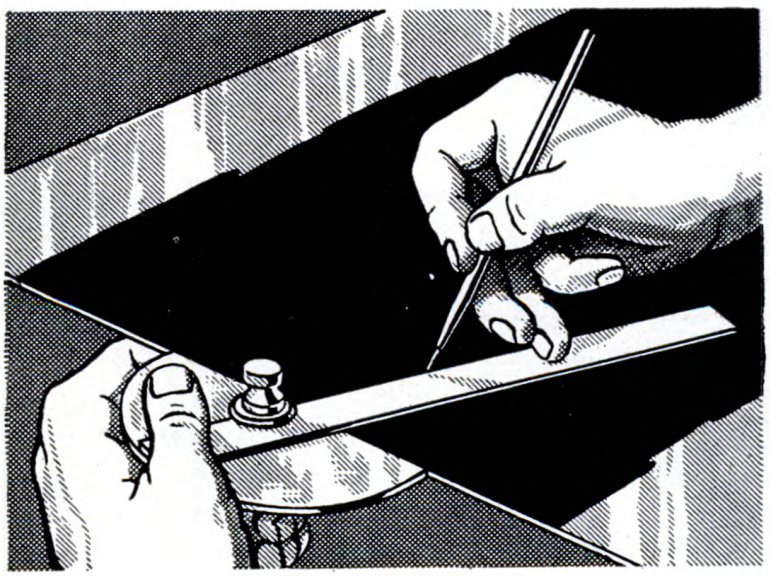


Figure 38.—The protractor at work.

For laying out any angle, other than 90° or 45°, the PROTRACTOR is tops. Set it to the desired angle on

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the semi-circular scale that's graduated in DEGREES. Two locking screws prevent the protractor from slipping out of adjustment.

A simplified type of protractor is shown in figure 38.

When you use any square by holding the stock or head against a squared edge or surface, hold it TIGHTLY AGAINST THAT SURFACE. Keep the blade of the square in contact with the surface you're marking to prevent the scriber from slipping under the edge.

HANDLE ALL SQUARES WITH CARE. If you have one that's dented, cracked, or sprung, it's worse than useless. Don't DROP THEM on the deck or throw them in the tool box with other tools. You handle your wrist watch with extreme care. Treat your squares with the same consideration.

PUNCHES

When you swing an arc with the dividers, you swing it from a point located at the INTERSECTION OF

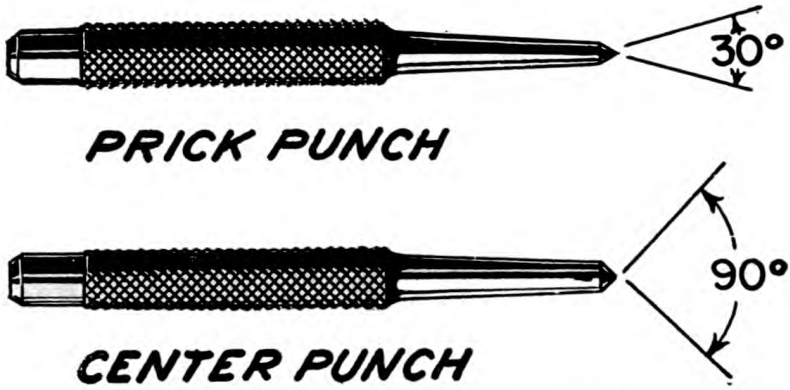


Figure 39.—Prick punch and center punch.

TWO LINES. If you placed one point of the dividers on the intersection, it would slide away, unless you had PRICK PUNCHED the intersection. The small indentation made by the prick punch provides a seat in which to pivot the divider point.

The prick punch, figure 39, is 4 or 5 inches long, with a knurled grip and a ROUND, SHARP point. To

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make the mark, tap the prick punch lightly with a light (4 oz.) ball peen hammer.

There's a little trick you can use to get the mark EXACTLY IN THE CENTER of the intersection. Just drag the point of the prick punch along one of the scribed lines until you feel it hit the other line. Then straighten the punch and tap it with the hammer.

Now CHECK the location with your EYE and with the RULE. Hold the rule ON EDGE and measure from

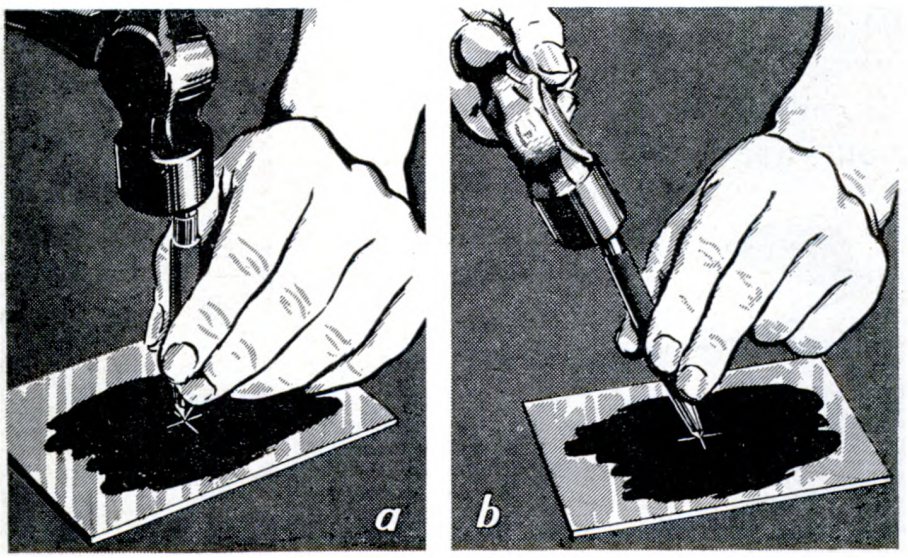


Figure 40.—Using the prick punch.

the one inch mark. Is the punch mark where it belongs? What if it's off-center? Try to DRIFT it over, as shown in figure 40*b*. Place the point in the mark and tap the punch in the desired direction. TAKE IT EASY, because you don't want any foxholes on the layout.

CENTER PUNCH

The prick punch marks that locate the CENTERS OF HOLES may be enlarged with a center punch just before the hole is drilled. It has a wide angle (about 90°) and is used to guide the drill when the hole is made. Use an 8 or 10 ounce hammer and hit the

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center punch ONE SOLID BLOW. Be sure you hold the punch exactly perpendicular to the surface.

When you grind either type of punch, rotate the point to keep it round. Be sure you maintain the proper angle for the punch you're grinding. Don't let it get hot enough to turn blue or black—that will soften the point. To prevent overheating, dip the point in water at frequent intervals.

SPECIAL LAYOUT TOOLS

You'll find that most of your layout is done with rule, scriber, dividers, and squares, but what about IRREGULAR CURVES?

Some tools used as guides for marking curved line layouts are shown in figure 41.

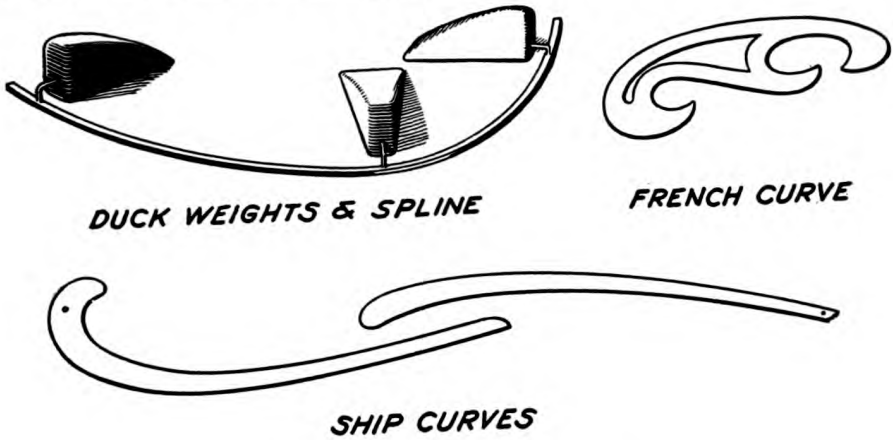


Figure 41.—How about a curve?

Small irregular curves are easily handled with a FRENCH CURVE. They are obtainable in several shapes and styles.

For larger and longer curves, use the SHIP CURVE or the SPLINE and DUCK WEIGHTS. In the lofting room, the spline and duck weight system is necessary to lay out ship and boat curves full size.

Irregular curves are drawn through fixed points on the layout. Try to fit the outline of the tool to AT LEAST THREE POINTS AT ONE TIME. Be sure the curve is smooth and unbroken.

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Ships curves and French curves are ordinarily made of transparent plastics. Without proper care and stowage, nicks and scratches will develop rapidly and they're about as good for curves as an 1890 bathing suit.

SPEED OR ACCURACY?

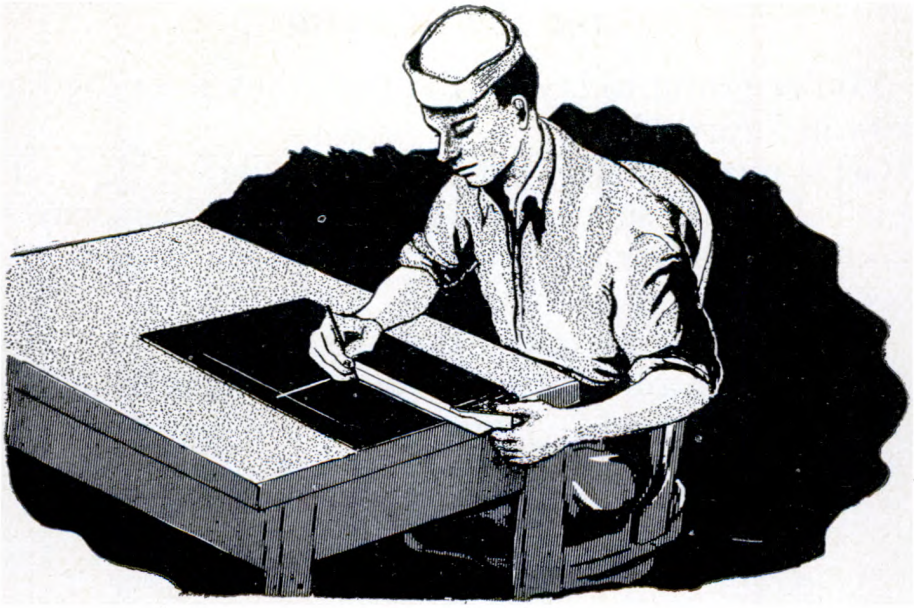
Take your time so you will HIT THE TARGET. If you mess up a layout you'll have to start all over. Do your best to get an ACCURATE LAYOUT the FIRST TIME. Speed will develop with PRACTICE and EXPERIENCE.

You won't have much layout trouble if you TAKE IT EASY and CHECK EVERYTHING carefully as you go along.

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CHAPTER 7

LAY IT OUT

ON LOCATION

What cameraman would start shooting pictures before the set was on location?

Your problem isn't so different from his. You've got to get your "set" on location before you can wield your scriber and square.

When you've got the blueprint, the stock, and layout tools in front of you, you've got the props. But the location?

Where's the best place to work?

Whenever possible, work on a smooth, flat bench or table top. Keep that surface clear of chips and filings. If the surface is rough or scratched, put a piece of wood or heavy paper under the stock.

If you're using a large piece of stock, ask someone to help you place it on the bench. Cut stock with care and avoid damage to the part you don't need. Leave it in good condition for the next man. If you protect your stock during the layout, you make things easier for yourself when you finish up the piece.

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THE JOB AT HAND

You're going to layout the part shown on the blueprint in figure 44.

Get a piece of steel plate 3/16″×2¾″×5¼″. The finished part is smaller but you need a little leeway for making an accurate layout. In this case about ⅛″ was allowed around the part.

The layout man calls the SURFACES of the stock FACES, EDGES, and ENDS. He also speaks of thickness, width, and length. Dimensions are given in that order. It's all made clear in figure 42.

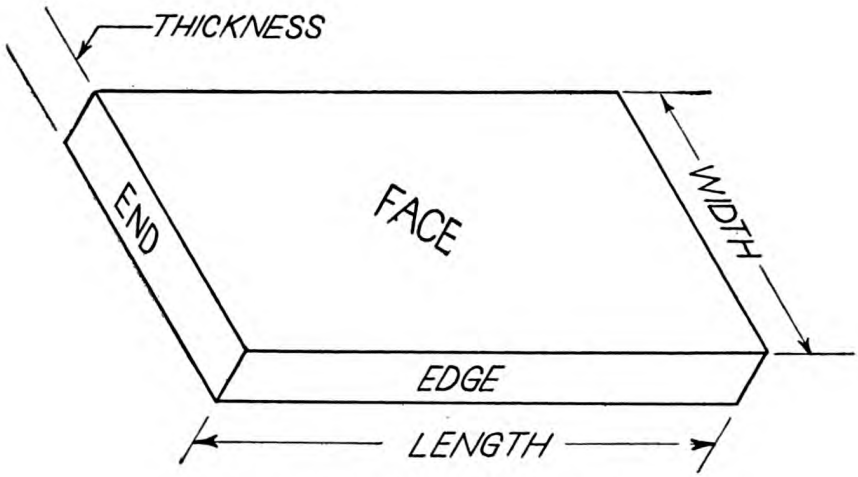


Figure 42.—Layout terms for a piece of stock.

The layout procedure for this part is given step-by-step. Follow along carefully. Remember that this is steel—BUT the same layout principles and procedures apply to ANY shop job.

SQUARE IT UP

Much of your layout work will be done with your combination square. The square won't do an ACCURATE job unless it's stock (or head) is held against a straight and square surface. That's why you have to SQUARE UP ONE EDGE and ONE END of your stock.

Get out a 10″ smooth file and REMOVE THE BURRS left on the stock when it was cut out. BE CAREFUL,

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because those rough edges can send you to sick bay with a badly cut finger.

Now square ONE EDGE of the piece of stock. It must be STRAIGHT and form a RIGHT ANGLE with the layout surface or face. File it until it CHECKS TRUE with the square.

Now square the LEFT END. It must be straight, form a right angle with the layout surface, and be at a right angle with the SQUARED EDGE.

Don't be satisfied with a half-way job. Those surfaces HAVE TO BE squared. You're going to use them when you lay out ALL your HORIZONTAL and VERTICAL LINES.

WATCH THE CORNERS. It's easy to round them off. KEEP THEM SQUARE.

CAN YOU SEE IT?

You may scribe lines as skillfully as Varga turns out a pin-up. But, unless you can SEE those lines, they

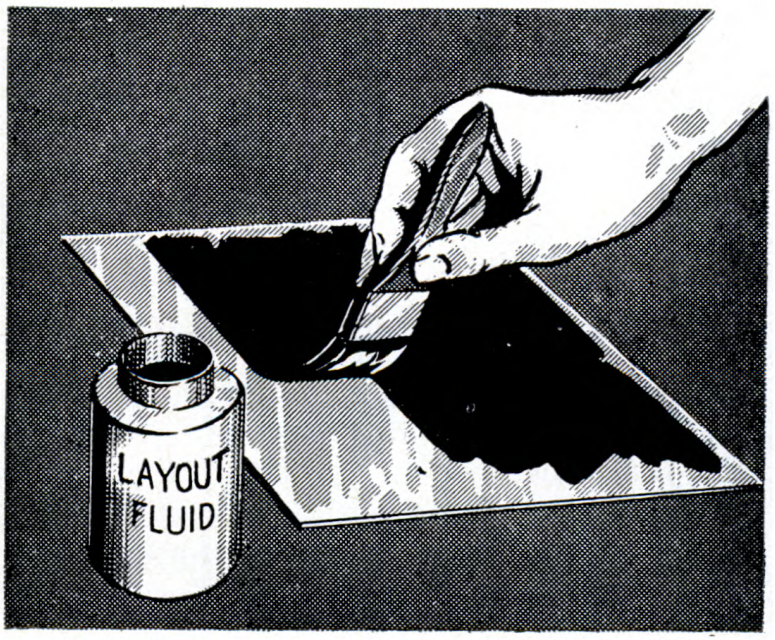


Figure 43.—A good background for scribed lines.

won't do you any good. Layout lines are hard to see on a steel surface unless you make them STAND OUT.

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Here's where LAYOUT FLUIDS come in. They furnish a background that contrasts with the scriber lines. They also kill reflection and glare.

LAYOUT DYE

Use LAYOUT DYE if it's available. It's a purplish blue color and a thin coat dries in five minutes.

Layout dye will not work on an oily, dirty, or rusty surface. Clean the surface thoroughly with emery cloth. Apply the dye with a brush as shown in figure 43. Brush it on quickly and don't go over it a second time to "touch it up." KEEP IT THIN.

You can eliminate the brush if you use a small wad of cloth. Dip it in the layout dye and quickly smear it on the surface.

ZINC CHROMATE

If you don't have layout dye, use ZINC CHROMATE. It's yellow and dries fast. Just clean the surface and brush on ONE THIN coat. Let it dry and you have an excellent background for scribed lines.

Zinc chromate prevents rust and corrosion. The Navy uses it extensively as an undercoat for paint and enamel on ships, boats, and planes. You should be able to secure it on any ship or station.

COPPER SULPHATE

You can use a COPPER SULPHATE SOLUTION on iron and steel. Just smear it on the clean surface with a brush or rag. A chemical reaction causes a coating of copper to be deposited on the iron or steel.

Don't try to use copper sulphate on ALUMINUM or other NON-FERROUS METALS.

You won't need to use any layout fluid on GALVANIZED IRON. Scriber lines will show clearly on the zinc coating.

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SIZE UP YOUR JOB

While the layout fluid dries, take a look at figure 44. It's the blueprint of the part you're going to lay out. The part is a small ANCHOR PLATE FITTING used to hold down other parts.

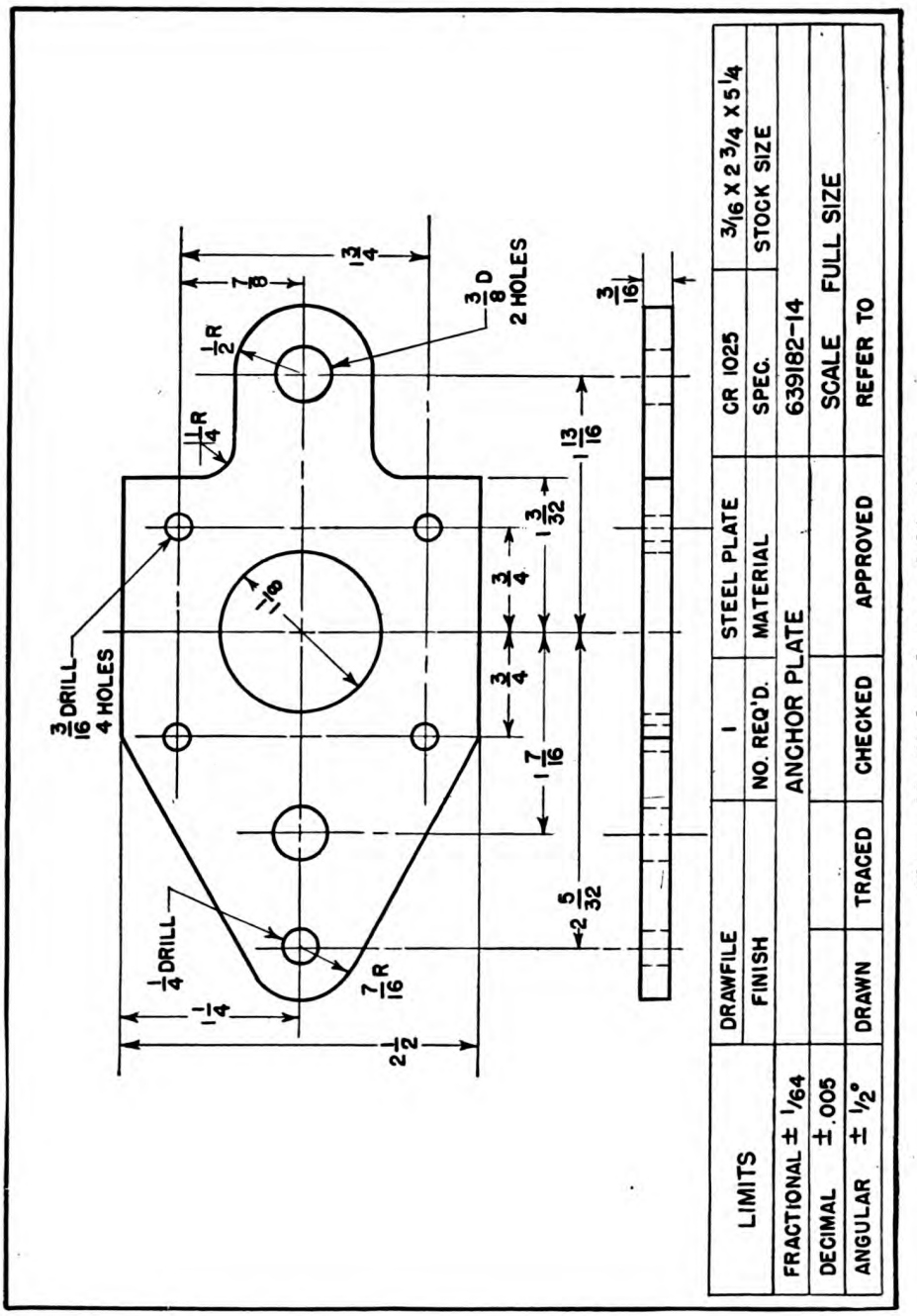


Figure 44.—Make a layout of this piece.

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You can see that the HOLES in this anchor plate are IMPORTANT. Bolts, studs, and shafts will go through these holes into matching holes in other parts. The layout for the holes will have to be extremely accurate so you'll need a LAYOUT PROCEDURE that provides the UTMOST ACCURACY OF HOLE LOCATION.

For some jobs, especially those made of sheet metal or wood, you might use the REFERENCE EDGE method, figure 45. It utilizes the squared edges. It's NOT the best method for ACCURATE work.

Another method is the REFERENCE LINE method, also shown in figure 45. It starts with an important edge line.

You want to start with IMPORTANT CENTERLINES so you'll use a MODIFICATION of the reference line method. Let's call it the BASIC CENTERLINE METHOD. You'll use it to lay out the anchor plate shown in figure 44. It's ACCURATE.

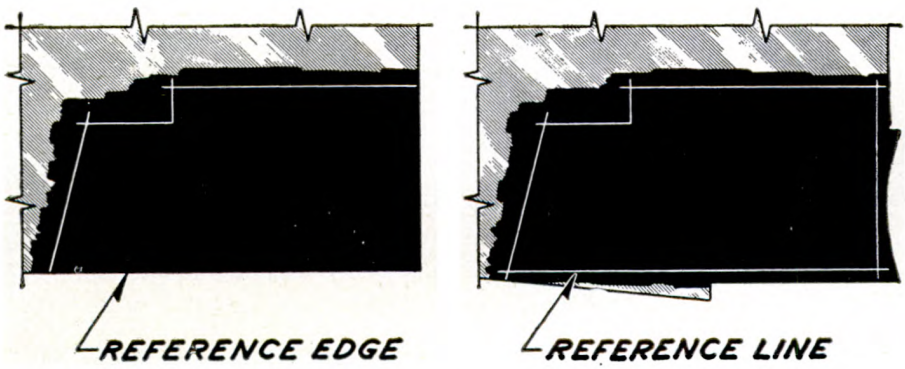


Figure 45.—Reference edge and reference line.

BASIC CENTERLINES

Which centerline is the most important? Which one seems to be the FOUNDATION of the drawing, the BASIS for the other lines? It's the horizontal centerline through the center of the part, the one that passes through the centers of four holes. Call it your BASIC HORIZONTAL CENTERLINE.

You'll use the other centerline that passes through the big hole for your BASIC VERTICAL CENTERLINE.

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ALL MEASUREMENTS for locating holes will be made from these two lines and from their INTERSECTION—the point where they cross.

Now to locate and scribe these two basic centerlines. Place them carefully to avoid running the layout OFF the surface of the stock.

Look at the dimensions at the left of the top view, figure 44. The basic horizontal centerline divides the part into halves, so put that line through the CENTER of your layout surface. Locate it with your rule and guide the scriber with the square blade. Hold the square stock against the SQUARED END. This line must be PARALLEL TO THE SQUARED EDGE.

Now for the basic vertical centerline. How far will you mark it FROM THE LEFT END of the stock?

The distance from the basic vertical centerline to the center of the hole at the left end is 2-5/32". To this dimension add the RADIUS of the arc at the left end, 7/16". You need some leeway so add another 1/8". The total distance from the left end to the basic vertical centerline is equal to 2-5/32 + 7/16" + 1/8" or 2-23/32".

Hold your rule ON EDGE along the basic horizontal centerline with the ONE INCH MARK on the LEFT EDGE of the stock. Now mark at the 3-23/32" mark with your sharply pointed scriber. Mark it lightly. Now use your square and scriber to scribe the line through that mark. Hold the square stock hard against the SQUARED EDGE. This basic vertical centerline must be PERPENDICULAR to the basic horizontal centerline.

When you're sure BOTH basic centerlines are accurately placed, PRICK PUNCH THEIR INTERSECTION. Your layout should be just like figure 46*A*. This point of intersection is your BASE POINT for completing the layout. It's labeled *O* so you can keep track of it. When it's possible to do so, measure from this point to locate other points. This BASE POINT is also the center of the large 1 1/8" hole.

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LOCATE THE HOLE CENTERS

How far from the base point are the two vertical centerlines that help locate the four small 3/16″ holes? You'll measure this distance on the basic horizontal centerline on EACH SIDE of the base point. Here's how.

Set your dividers at ¾″ by the rule. Check this setting carefully. Now use the base point *O* for your CENTER and swing short arcs across the basic horizontal centerline. These arcs locate points *a* and *b,* figure 46*B*.

Use the same method to locate the centers for the two ⅜″ holes and the one ¼″ hole. In each case, swing the dividers from the basic point, *O*. Check your measurements, then use your scriber and square to lay out vertical centerlines through the intersections. Now PRICK PUNCH THESE INTERSECTIONS, *a, b, c, d,* and *e*.

Now get the two horizontal centerlines for the four 3/16″ holes. The dimension shows these lines to be ⅞″ from the basic horizontal centerline. Set your dividers for ⅞″ and swing arcs from centers *a* and *b,* as shown in figure 46*B*.

Connect these arcs with TANGENTS (straight lines) to form the two centerlines. Prick punch the hole centers and your layout should look like figure 46*B*.

Now scribe in the holes and swing the two end arcs. Check each arc radius carefully. It's good layout practice to start with the smallest radius and end up with the largest.

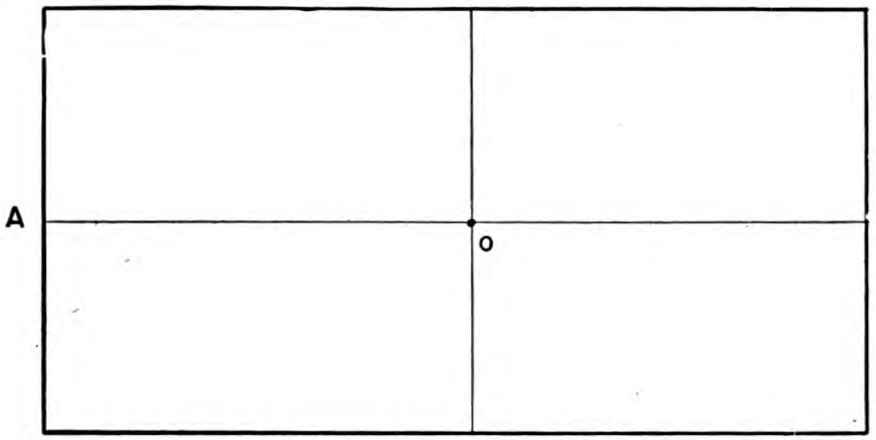
Your layout should now correspond to figure 46*C*.

FINISH THE OUTLINE

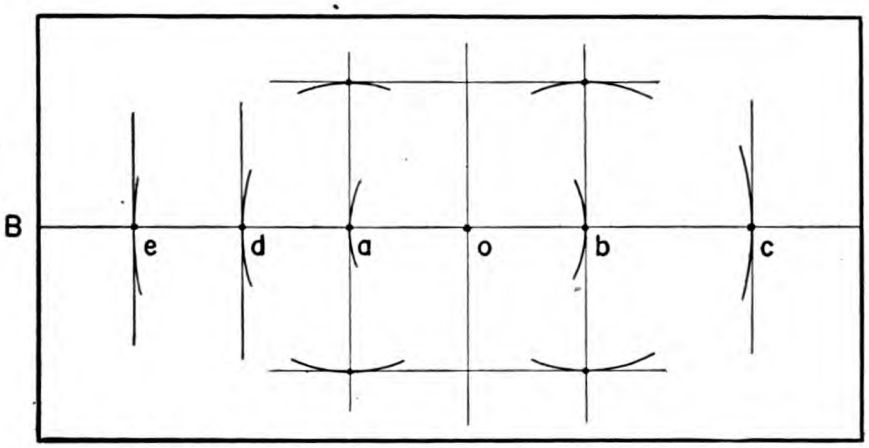
You have part of the outline—the arcs at the ends of the anchor plate. How can you ACCURATELY lay out the remainder of the outline?

First get the top and bottom outlines. Set the dividers for 1¼″ and swing arcs *f, g, h,* and *k* from

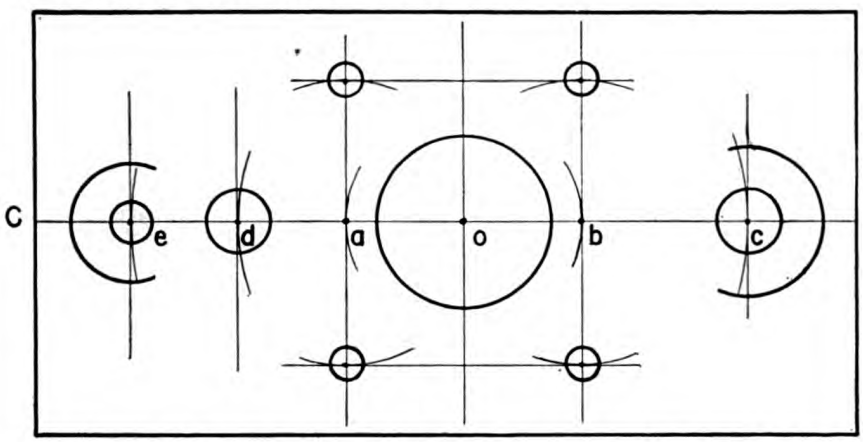
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BASIC CENTERLINES AND BASE POINT



LOCATING THE HOLE CENTERS



SCRIBING CIRCLES AND ARCS

Figure 46.—Layout steps *A, B, C.*

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centers *c* and *d*, as in figure 47*D*. Scribe the tangent lines through these and that's that.

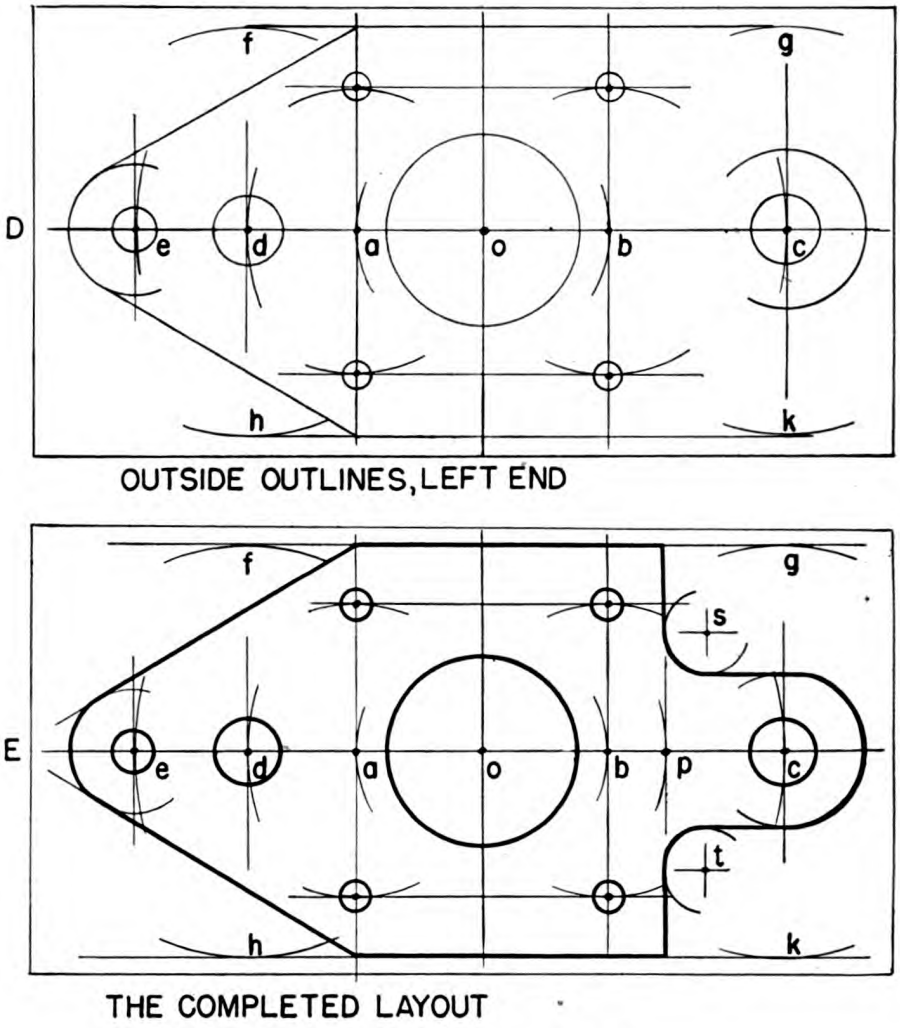


Figure 47.—Layout steps *D* and *E*.

Now for the SLANT LINES of the LEFT END. Each one is TANGENT TO THE LEFT END ARC and runs through the INTERSECTION of the horizontal outline and the vertical centerline through point *a*. Line up your rule so that the edge passes through that point and is tangent to the arc. Scribe the lines in and your layout should be like figure 47*D*. Now for the right end—

The vertical lines forming the right end outline are located by setting the dividers at 1-3/32″ and

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swinging the arc through point *p*. Scribe the line through this POINT of INTERSECTION. It is perpendicular to the basic horizontal centerline. The short horizontal lines of the right-end outline are scribed in TANGENT TO THE ARC and PARALLEL to the basic horizontal centerline.

Now locate the centers for the two ¼" radii at *s* and *t* and swing these arcs to complete your layout. It should be just like the completed layout, figure 47*E*.

It's time for a check-up. Check ALL dimensions for ACCURACY. Check the radii of the arcs and circles. Check all right angles to be sure they're exactly 90°.

You're satisfied it's RIGHT? Maybe so, but you should get an experienced layout man to give it the once-over. If your lines are off more than a few thousandths, he can point out the errors.

If the layout expert says it's OK, you're on your way as a layout man. If it's not OK, turn the layout over and make a fresh start on the other surface. That old rule, PRACTICE MAKES PERFECT, certainly applies to layout work.

WHAT'S NEXT?

PUT AWAY THOSE LAYOUT TOOLS!

Don't allow your layout tools to float around on the bench top with the files, hacksaws, drills, and hammers. Remember that your layout tools are PRECISION tools and must be handled with extreme care.

KEEP THE LAYOUT YOU HAVE MADE. If you understand the USE OF TOOLS, you can work it out with saw, file, and drill.

If you want MORE PRACTICE, try laying out the part shown in figure 48. You'll be ON YOUR OWN, so you'll have to THINK OUT your own LAYOUT PROCEDURE. The system you used for the layout of the anchor plate fitting can be applied to any layout. It's up to YOU to make the application.

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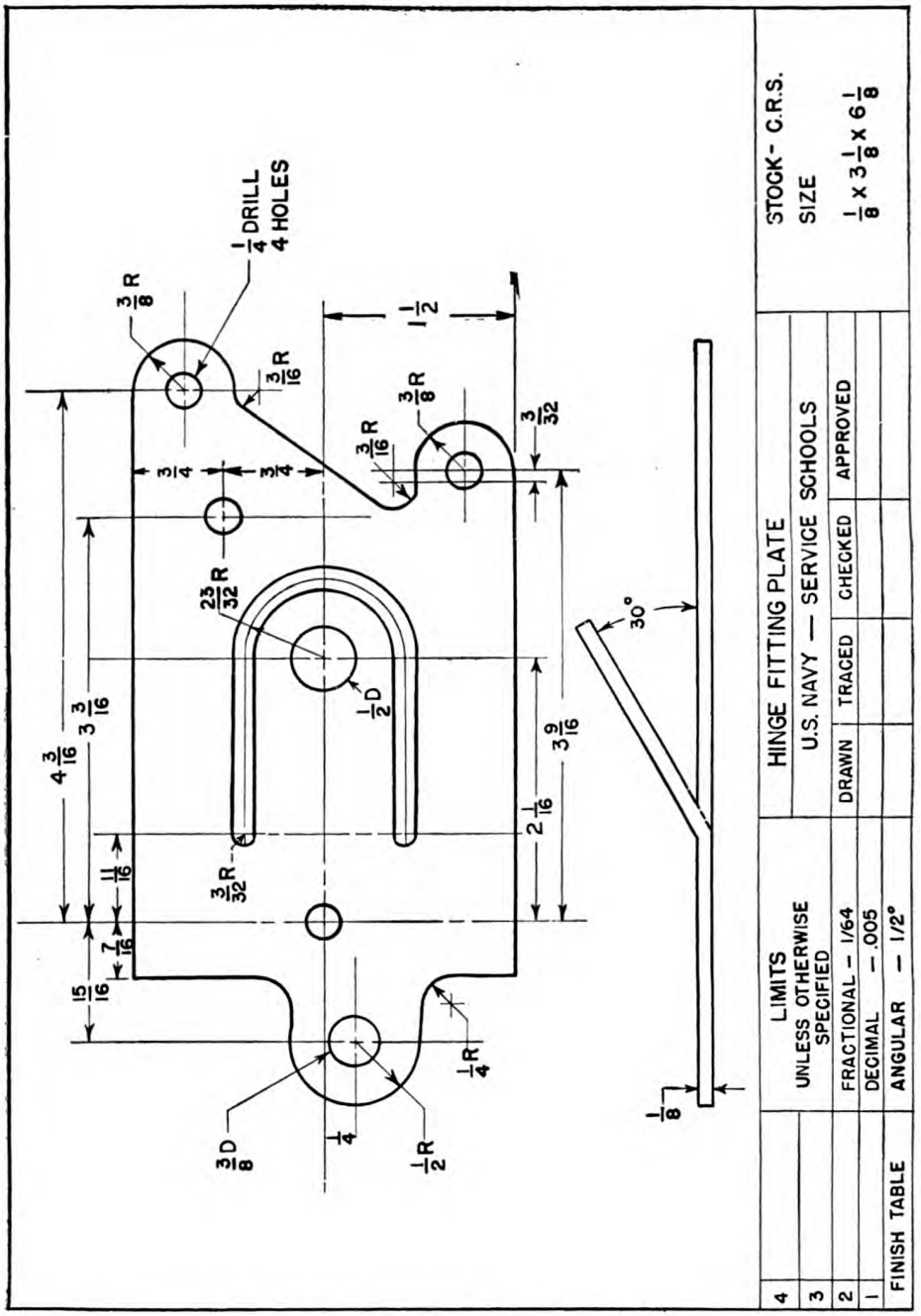
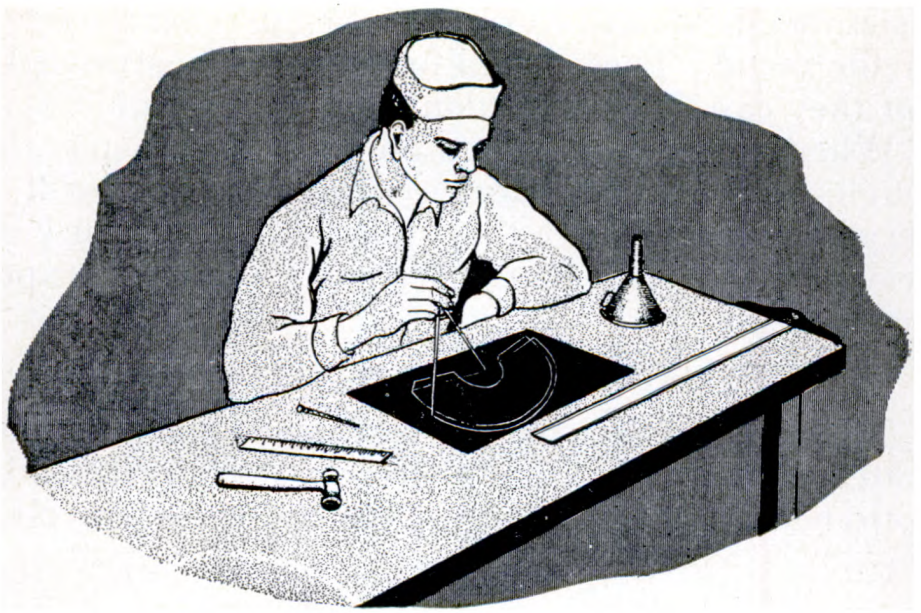


Figure 48.—Practice layout problem.

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CHAPTER 8

TIN-BENDER SPECIALS—DEVELOPMENTS

UNROLL IT

You had a hint back in Chapter 2 that curved surfaces have to be laid out IN THE FLAT before they can be rolled, bent, or otherwise formed into the desired shape.

Your job as a Navy technician may involve this type of layout work. The process of laying out for sheet metal objects is generally referred to as SHEET METAL DEVELOPMENT. The layout development can be made directly on the sheet metal surface. Or you can develop a PAPER PATTERN and TRANSFER the development to the metal sheet.

The metalsmith who works with sheet metal is commonly referred to as a "tin-bender," just as the carpenter is called a "wood-butcher" and the cook referred to as a "hash-slinger." "Tin-benders" must know the kind of developments necessary for such sheet metal objects as boxes, funnels, buckets, cans, and pipe elbows.

Before you start to develop a layout on a piece of

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sheet metal, be sure to remove the burrs on the edges of the metal. These small burrs are almost invisible but they can do a lot of damage to your hands.

When you make layouts on paper, use a piece of tough, heavy paper. Brown wrapping paper will do very well. Get a piece that's plenty large because developments usually take more space than you expect them to.

STRETCH IT OUT—ANGULAR DEVELOPMENT

The simplest form of angular development is illustrated in figure 49. It's a plain box with a rectangular bottom and straight sides. The principles involved

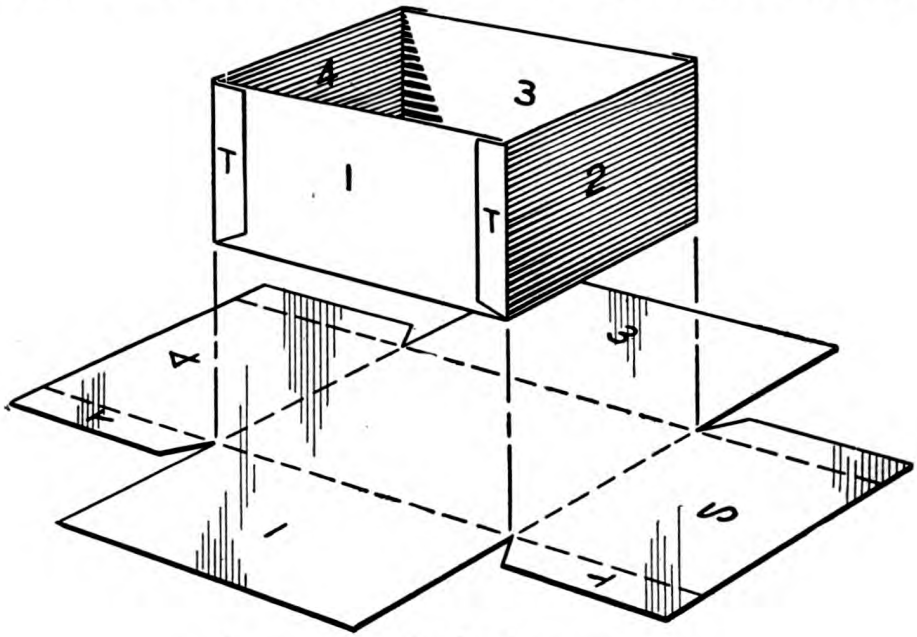


Figure 49.—Angular development of a box.

are easy to understand—but what LAYOUT PROCEDURE will you use?

One method is to square the sheet metal stock to the EXACT OVERALL DIMENSIONS, then lay out all other lines from these square edges and ends.

An alternate method is based on two perpendicular centerlines. All measurements are made from them. Follow the same procedure you used for the anchor plate layout.

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For most box layouts made on paper you need to develop only one-fourth of the pattern. This quarter-pattern is cut along the center lines and transferred to the metal by lining up the centerlines of the pattern with centerlines on the metal.

Here's one thing you have to watch. Don't forget those laps or TABS, as indicated by *"T"*, figure 49. They provide a means of fastening the box together. Be extremely careful when you cut out a developed pattern or you may snip off one of those tabs.

It's so easy to make an angular development like the one in figure 49, that you won't need any practice on that type. Just for practice, layout the development of the flared-end box shown in figure 50. Secure a piece of heavy paper about two feet square, break out your layout tools, find a flat surface to work on, and get going.

Start with the bottom. It's 6″ × 9″. Measure and lay out carefully, making sure the corners are RIGHT ANGLES. Now locate and mark the outside lines marked *d*—they're 6″ from the bottom lines and they extend 1½″ past the bottom lines at each end.

BOOBY-TRAP

Layout lines *a* and *b* for each corner. Extend line *c* and locate line *e*. Here's the "booby-trap" of this layout. Line *e* IS NOT 6″ from the parallel bottom line—it's more than 6″. Take a closer look at the picture of the box and you'll see that line *c* is equal to the length of line *a* plus the length of line *b*. Check this part of the development carefully.

When you have finished the main outline, layout the tabs and mark the bend lines. Check all your measurements carefully, then cut out the pattern and form it up to test the ACCURACY of your development.

If the ends and sides are FLUSH along their edges, you have successfully completed a type of angular development that is often used.

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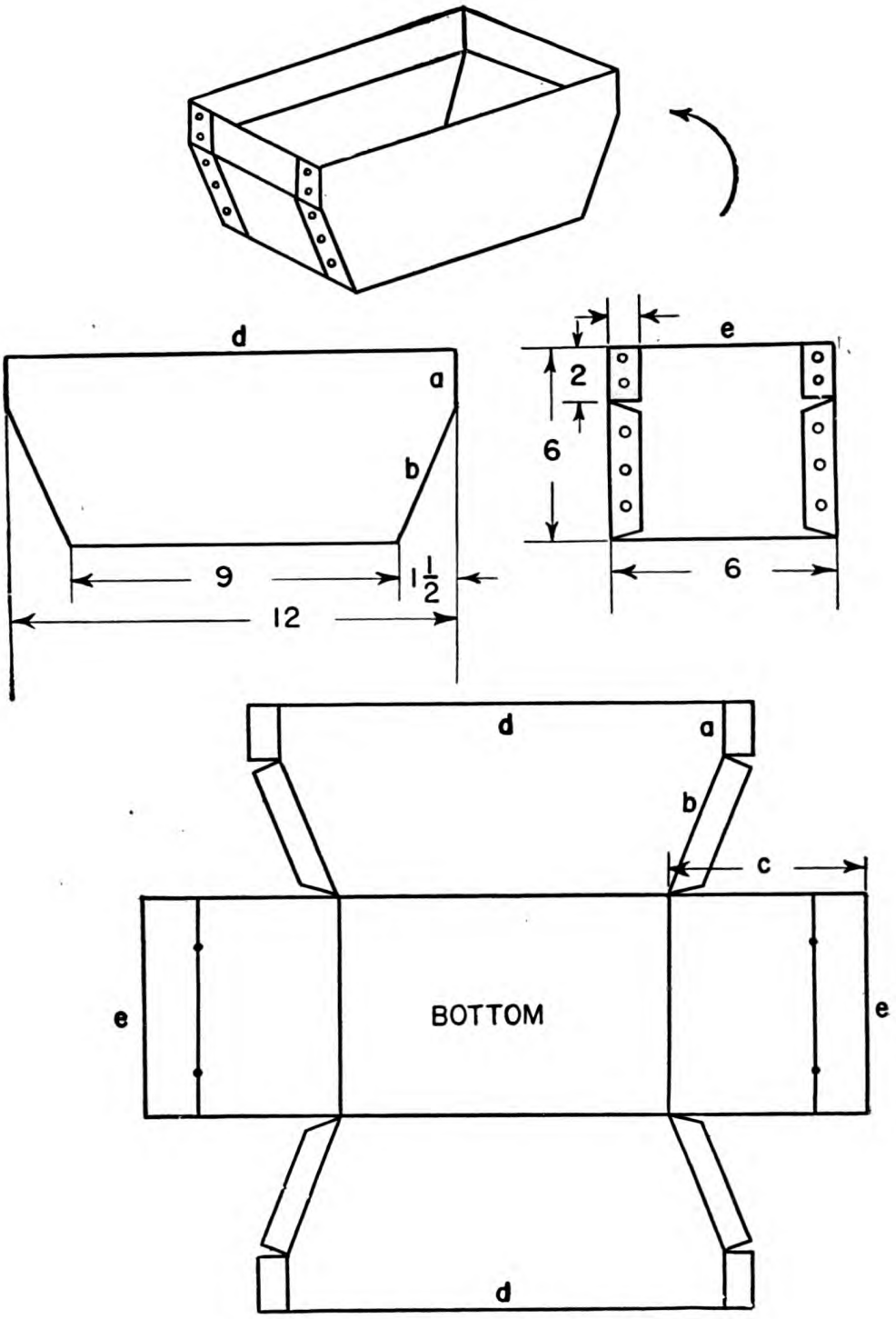


Figure 50.—Development of flared-end box.

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ROLL IT OUT—PARALLEL DEVELOPMENT

You won't have any trouble making a development for a plain sheet metal cylinder. It's just like unrolling a rug. Once you know the diameter all you have to do is figure the circumference (πD) and allow extra

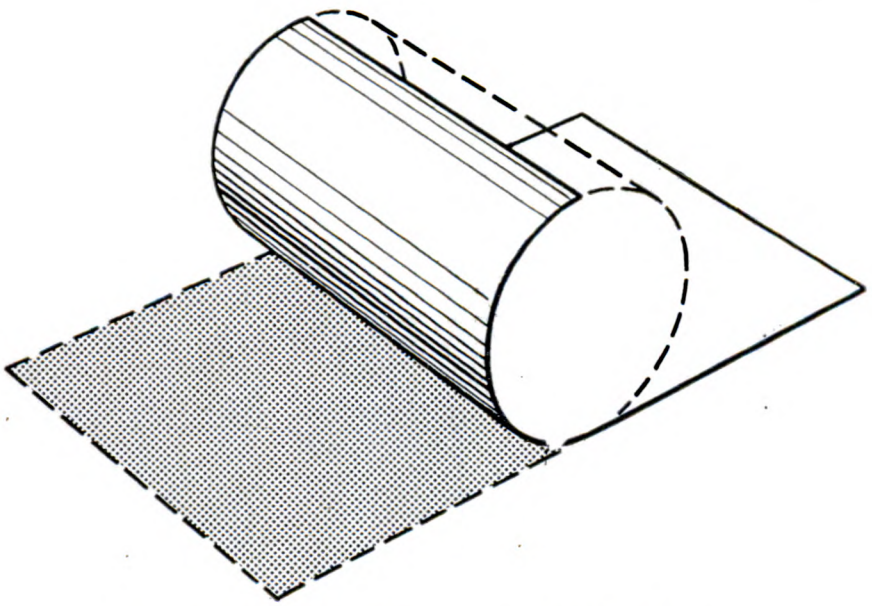


Figure 51.—Cylinder roll-out for parallel development.

metal for the seams. Figure 51 shows the principle of a cylindrical object laid out by a parallel development. It's very simple—BUT how about the cylinder that has been cut at an angle?

Such a cylinder is shown in figure 52. Looks like a tough layout job, but it's simple when you follow directions. All those numbers are put on the layout to HELP YOU MAKE THE LAYOUT. As you develop this layout keep careful track of those numbers by labeling them, both on your two orthographic views and on your development.

You need a piece of paper about 24″ × 40″ for this job. If paper that size is not available, try making everything one-half size.

Start your layout by constructing the orthographic front and top views. These views must be ACCURATE

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because the development is made from them.

Make the left outline of the front view (line 7) ten inches long and the right outline (line 1) four inches long. The slant line connects the top ends of these two

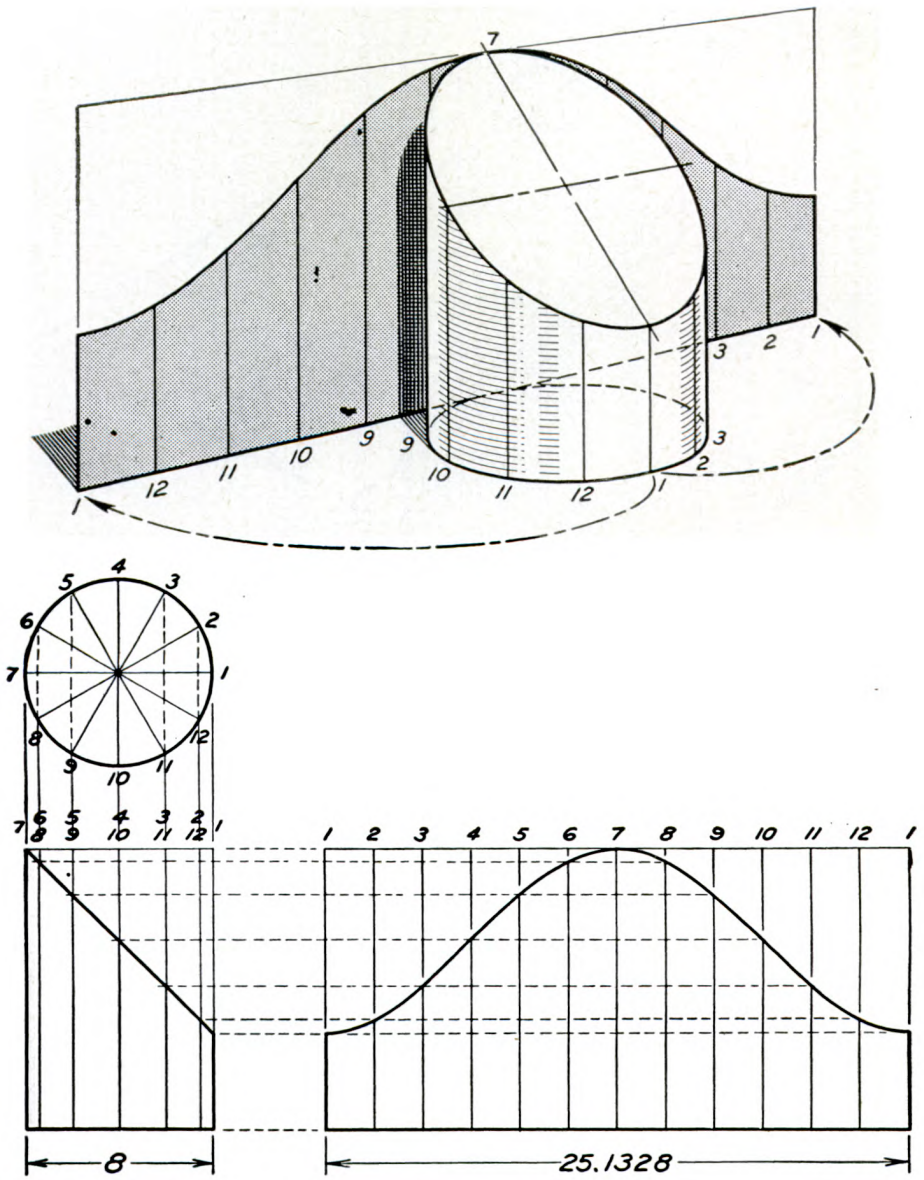


Figure 52.—Parallel development problem.

lines. Draw the 8″ circle that forms the top view and divide it into 12 equal parts. Number these from 1 to 12, as in figure 52.

Drop vertical lines from these twelve points so

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that they intersect the slant line of the front view. Some of the lines coincide so you'll only have five new ones. Number them at the top of the front view.

What about the development? Start it with the base line, which is equal to the circumference of the eight-inch circle. Erect vertical lines at each end and divide the intervening space into 12 equal spaces. Make these lines 10 inches long and label them at the top.

Now construct horizontal lines through the intersections of the front view and across the vertical lines of the development. All the points of the curve are now located. Use the points to sketch in the curved lines. You can "fair up the curve" with a French curve or ship curve.

Check the finished development, cut it out, and form it into a cylinder. The curved edge should now fit against a flat surface. The picture at the top of figure 52 shows how your developed pattern should look and work.

If you lay out this type of job on metal be sure to ADD material for making the necessary seams.

THREE-PIECE ELBOW

Not all parallel developments are as simple as the one in figure 52. You can expect more complicated shapes that require more complicated developments.

For a two-piece, 90° cylindrical elbow you would make each half by the method shown in figure 52, except that the slant line would have to be exactly 45°.

But what about a three-piece, 90° elbow, like the one in figure 53? Notice that the three parts of this elbow are portions of cylinders. You'll use the same system of parallel development, but it requires some special preparation.

To start this layout draw the view shown at the right in figure 53. Erect a RIGHT ANGLE from point *A*. Measure off the height of the elbow along *AD*.

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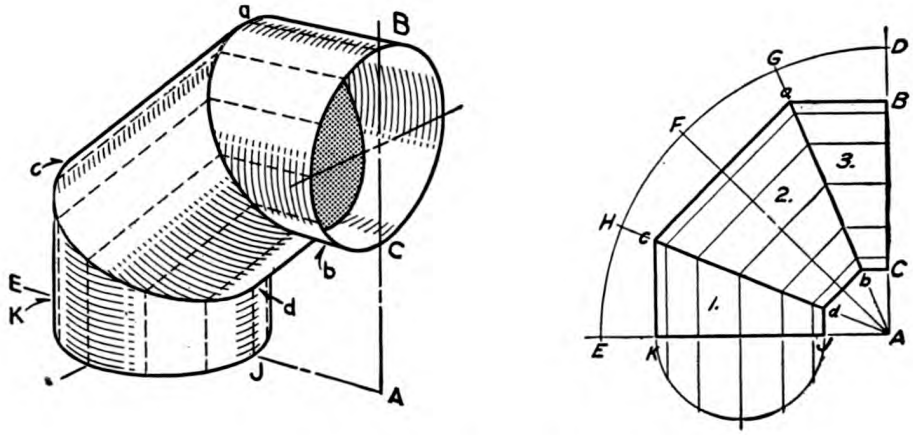


Figure 53.—Develop a three-piece elbow.

Measure off the diameter of the elbow from B to C. Swing the arc DE with any convenient radius, with A as the center.

Now divide the angle EAD into four equal angles with lines FA, HA, and GA. From points B and C draw horizontal lines to intersect radial line GA. Establish points K and J the same distance from A as are B and C. From K and J run vertical lines to intersect line HA at c and d. Connect points a and c and points b and d to complete the view of the elbow.

Now make developments of each of the sections. Check carefully and cut out the three sections. Put them together with transparent tape. If the three

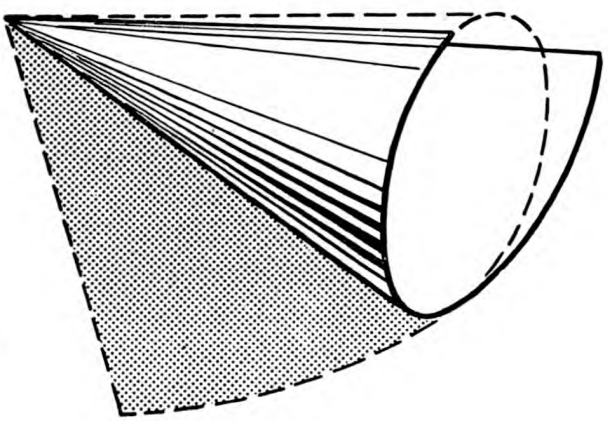


Figure 54.—Unrolling the cone.

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pieces fit together, form a 90° elbow, and are the desired diameter, you have made the development correctly.

SWING IT—RADIAL DEVELOPMENTS

The construction of a radial development is similar to that of a parallel development. In both cases the outside surface is unrolled.

Parallel development of a cylinder is like unrolling a rug; radial development of a CONE is like opening up and flattening out an ice cream cone.

You'll use evenly spaced reference lines in both cases. In one case the lines are parallel, like a picket fence. In the other case they radiate from the APEX of a cone like the spokes of a wheel. The parallel development reference lines were projected horizontally. In radial development the reference lines will be transferred from the front view to the development with the dividers.

The FRUSTUM OF A CONE is shown in figure 55. In case anyone asks you, a frustum is that part of a cone which is left when the top is sliced off. Here's how you develop it.

Draw the front and top views. Divide the base circle (top view) into 12 equal arcs by radial lines. Project lines from these intersections vertically downward to intersect the line *BC* of the front view. Connect these points of intersection with lines running to the APEX or point of the cone at *A*.

Now mark the horizontal lines through points *a, b, c, d, e, f,* and *g*. The distances measured along *AC* from *C* are TRUE LENGTHS and are used for the development.

Start the development by swinging an arc with a radius equal to *AB* or *AC*. Use any convenient point for the center.

Now set your dividers for 1/12 the circumference of the circle forming the top orthographic view. Step

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off twelve spaces around the development arc and run lines from these points to the center of the arc. Remember that it takes 13 lines to make 12 spaces. Number the corresponding points as indicated on figure 55.

The next step is to mark the true lengths of the

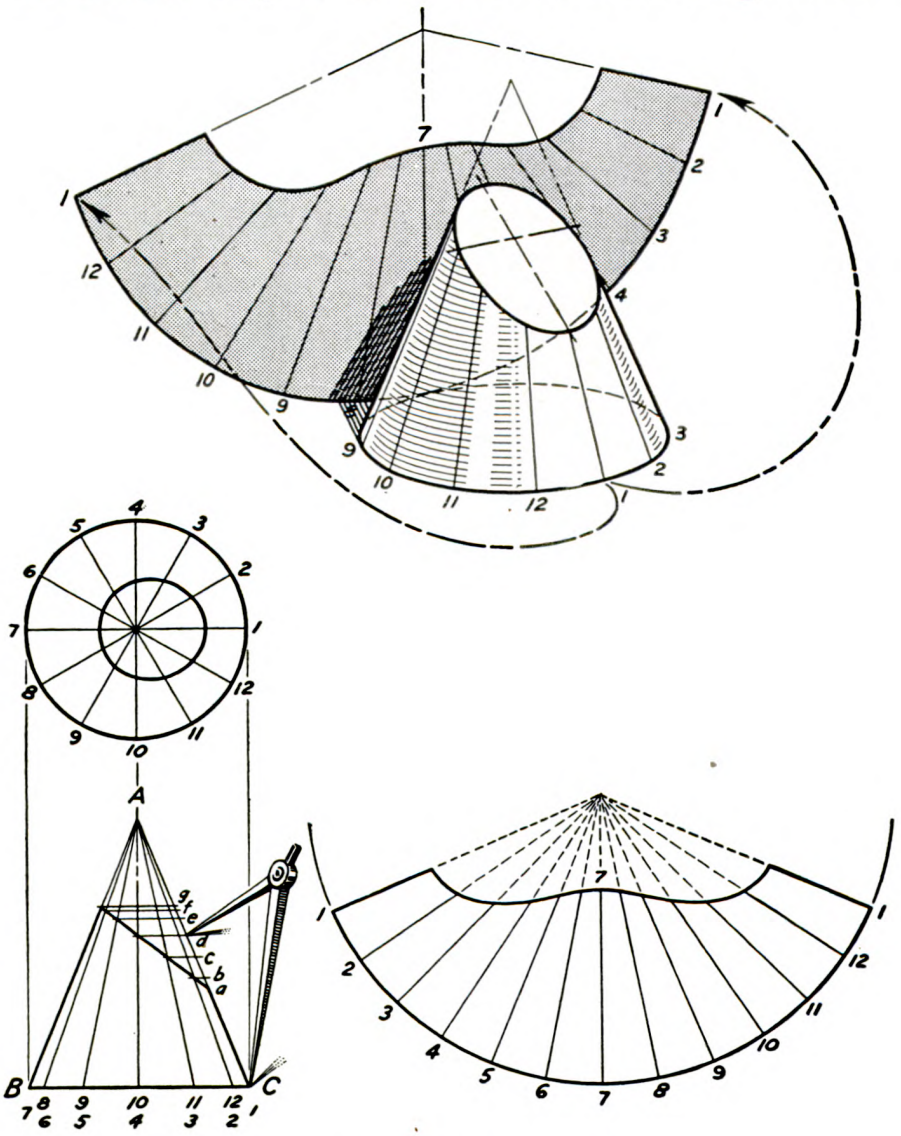


Figure 55.—Radial development of a cone.

lines on the development. To get the true length of line *1* set the dividers on *C* and *a* and transfer this distance to the development on the two lines marked *1*. In figure 55 the dividers are set for the true length

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of lines *4* and *10*. This distance is transferred to lines *4* and *10* on the development.

Complete these measurements and you have a point on each of the radial lines of the development. Fair a smooth curve through these points to complete the layout of the pattern for the cone frustum.

If you make a piece shaped like this for the ventilation system, don't forget to add the proper allowances for the seams.

TRANSITION PIECE

When developments of objects cannot be made by angular development, parallel development, or radial

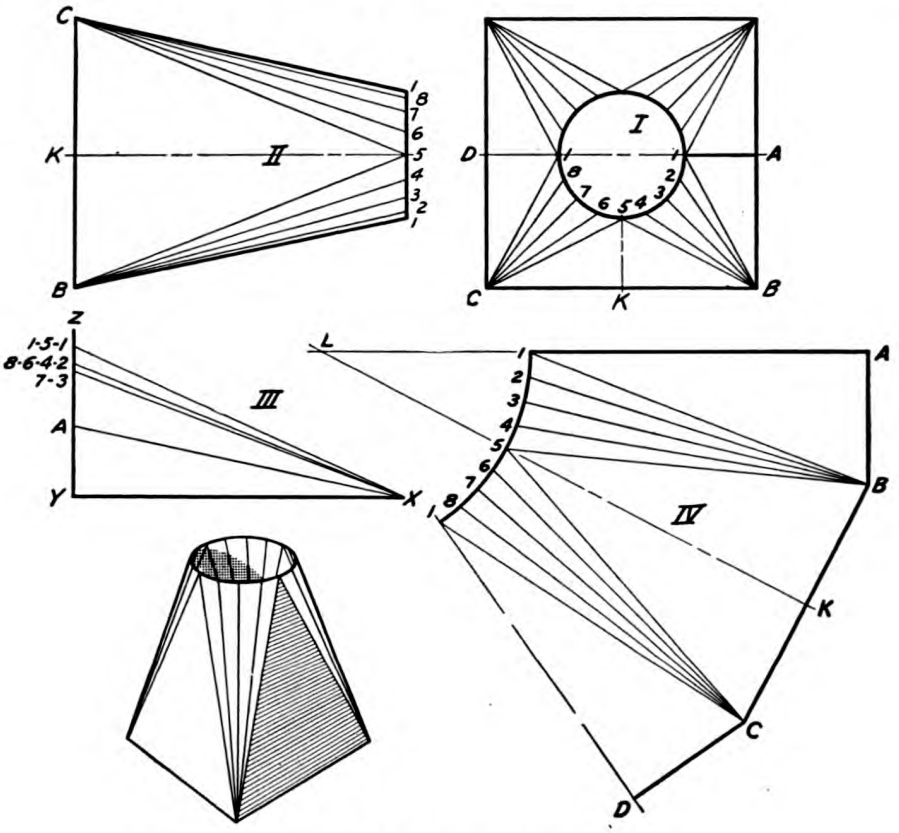


Figure 56.—Triangular development of a transition.

development, you'll have to fall back on a method known as TRIANGULATION. It is a system for finding and using the TRUE LENGTHS of lines.

One problem involving triangulation is an offset

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funnel, where the spout is not in the center. Another problem is a TRANSITION piece, such as is required to connect a square pipe or duct to a round one. The development for one of these transition pieces is shown in figure 56.

Here's your PROCEDURE for making this development.

Draw a circle and a square (view I) to represent the top view of the object. The dimensions are determined by the size of the two pipes to be connected.

In order to fit both pipes properly, the transition must have four flat triangular areas, which taper to a point at the circle; and four conical segments, which taper to a point at the corners of the square.

Divide half the circle (view I) into 8 equal arcs with your dividers, and connect the 5 points on each quarter of the circle with the corresponding corner of the square. Number the points. The lower half of the top view now shows half of the 4 conical segments and half of the 4 triangular flat areas. As this transition is symmetrical, it is necessary to draw only one-half of the object.

Project over to the left to construct side view II.

At some convenient location draw a horizontal line XY (view III) equal to the length of the transition piece. Erect the perpendicular YZ of an indefinite length.

The usual procedure in fabricating this transition from sheet metal would be to make the seam at $A1$, view I. This then is a logical place to start the development. To find the actual length of $A1$, transfer by means of your compass, the length of $A1$ in view I to the vertical line ZY in view III. On this vertical line mark point A. Then draw line AX, which represents the actual length of $A1$ on the transition top view, view I.

At some convenient place, draw line $A1$, view IV, and mark the ends.

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With your compass, measure the distance from *A* to *B* in view I, and with point *A*, view IV, as a center, swing an arc.

Find the actual length of *B*1 in the same manner as you found the length of *A*1, and transfer this distance to the development, using actual *A*1 as a radius and point *B* view IV as a center to swing an arc intersecting the short arc previously drawn with *A* as a center. Mark the intersection *B*, and draw straight line *AB*. This completes triangle *AB*1, view IV.

Set your compass to the length of chord 1-2 on the circle of view I, and then, in view IV, swing an arc with point *B* view IV as a center, to intersect the short arc previously drawn with point 1 as a center. Mark this intersection 2 and draw straight line *B*2. This completes two sides of angle 1*B*2.

Proceed in like manner to locate points 3, 4, and 5.

Line *B*5 is equal in length to line *C*5, and line *BC* in view IV is equal to line *BC* in view I.

Construct the triangle *BC*5 in view IV.

Locate points 6, 7, 8, and 1 in the same manner that you located points 1, 2, 3, 4, and 5.

Construct triangle *CD*1 which is similar to *AB*1.

Connect points 1, 2, 3, 4, 5, 6, 7, 8, and 1 with a smooth curve, completing half of the development. As the transition is symmetrical, use the first half of the development as a pattern to make the second half, thus completing the transition piece development.

If the two pipes were not on the same axis (out of line) it would be necessary to construct the entire development pattern by triangulation.

It is possible to simplify the transition development in figure 56 still further, as each quarter is equal. The procedure in brief would be—

Construct the triangle *AB*1, view IV.

Locate points 1, 2, 3, 4, and 5, view IV.

Construct triangle *B*5*K*. You know that this transition is symmetrical, so 1*A* must equal 5*K* and *AB*

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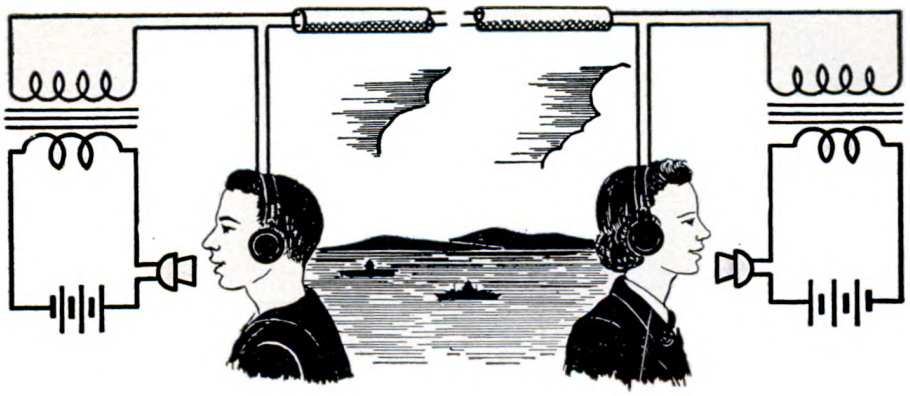
must equal *BK*. With the actual length of *AB* as a radius and point 5, view IV, as a center, swing an arc. Then with the actual length of *AB* as a radius and point *B*, view IV, as a center, swing an arc intersecting the one just drawn. Mark this intersection *K* and draw straight lines to complete triangle *B*5*K*. This establishes one quadrant (one-fourth of the development.)

Now project lines *A*1 and *K*5 until they intersect at *L*, to establish the center of the development.

From center point *L*, swing a radius that cuts through points 1 to 5.

If development 12345*KBA*1 is folded along line *LK*, it will form a correct development for 56781-*DCK*5.

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CHAPTER 9

ELECTRICAL BLUEPRINTS

DIAGRAMS AND SCHEMATICS

Men who know electricity best, "talk with diagrams." Ask them a question and they whip out a pencil and make a quick sketch to show you what's what. In telling a technical story, a single diagram is often worth more than a thousand words in putting over the POINT of the story.

One of two types of diagrams is generally used to explain electrical installations. You must understand these types before you try to read electrical blueprints or diagrams.

Certain structural parts of a circuit, as well as connection wires, are shown in a WIRING DIAGRAM. In a SCHEMATIC DIAGRAM, electrical parts are represented by SYMBOLS, and only the scheme of the connection is indicated.

The two diagrams in figure 57 show exactly the same thing. Both illustrate the connection pattern of coils in an electric motor. Note that the schematic diagram at the right uses a form of shorthand. You'll find it easy to make and read schematics when you know the symbols and their meanings and uses.

These symbols are applied to all types of electrical diagrams, including those for house circuits, ship cir-

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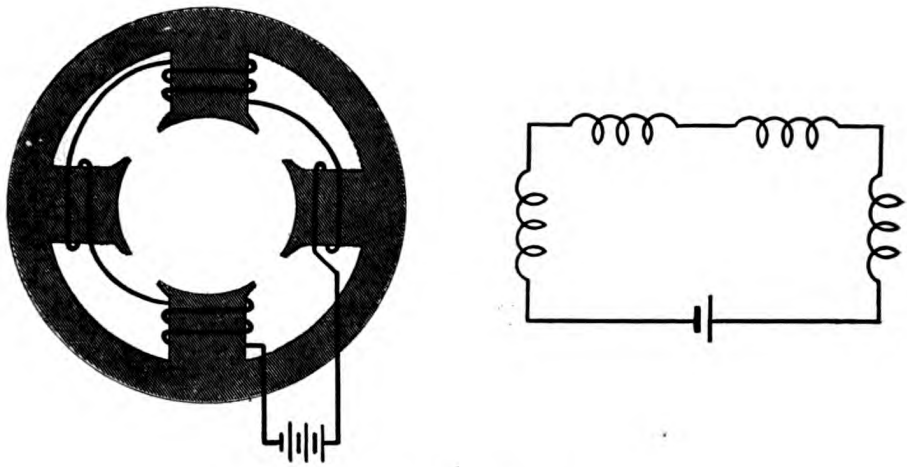


Figure 57.—Types of electrical diagrams.

cuits, engine ignition, telephones, and radio.

Learn the symbols in figure 58 and you will have no difficulty understanding electrical diagrams. There

E = VOLTAGE		V = VOLTS	
I = CURRENT		A = AMPERES	
R = RESISTANCE		Ω = OHMS	
f = FREQUENCY		~ = CYCLES PER SEC.	
+ = POSITIVE		— = NEGATIVE	
	VOLTMETER		GENERATOR (D.C.)
	AMMETER		MOTOR (D.C.)
	CELL (BATTERY)		MOTOR (A.C.)
	CONNECTION		GENERATOR (A.C.)
	NO CONNECTION		CAPACITOR, FIXED
	GROUND		TRANSFORMER, AIR CORE
	RESISTANCE (FIXED)		TRANSFORMER, IRON CORE
	RHEOSTAT		HEAD PHONES
	FUSE		MICROPHONE, CRYSTAL
	LAMP		SPEAKER, PERM. MAG.
	ARC		ANTENNA
	JACK (CLOSED CIRCUIT)		VACUUM TUBE (TRIODE)

Figure 58.—Electrical diagram symbols.

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are many other symbols used besides the ones in figure 58 but these will give you a good start.

Take a look at the schematic diagram in figure 59. Notice the two methods of representing wire connections for the three lamp and battery circuit.

By the method in *A,* you use a half circle or LOOP to show a crossing of two wires that are NOT CONNECTED. In method *A,* a connection is shown by two lines crossing or intersecting at right angles.

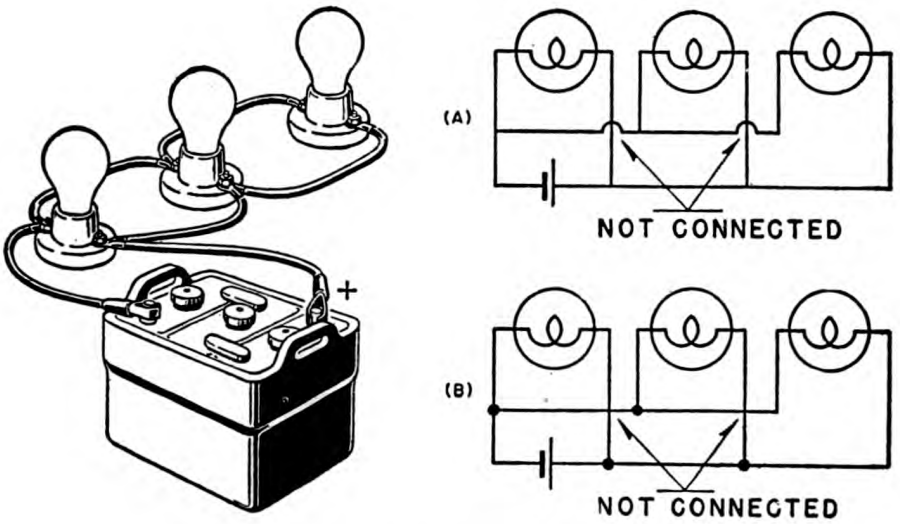


Figure 59.—Wire connections.

By method *B,* a crossing point of two wires is a connection ONLY if you place a DOT there.

Battlewagons have hundreds of sound-powered phones—connected in circuits to provide communications for the purpose of fighting and maneuvering. Figure 60 is a schematic wiring diagram of a head-set sound-powered phone.

If you work with boats you'll need to know about engine ignition systems. They're very much like automobile engine ignition systems and are shown in the same way. Study the wiring diagram for the four cylinder, V-type, power boat engine shown in figure 61 on page 93. Note how the symbols are used and

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how the wire connections are shown. It's a neat job and helps the engine mechanic to trace trouble in a jiffy.

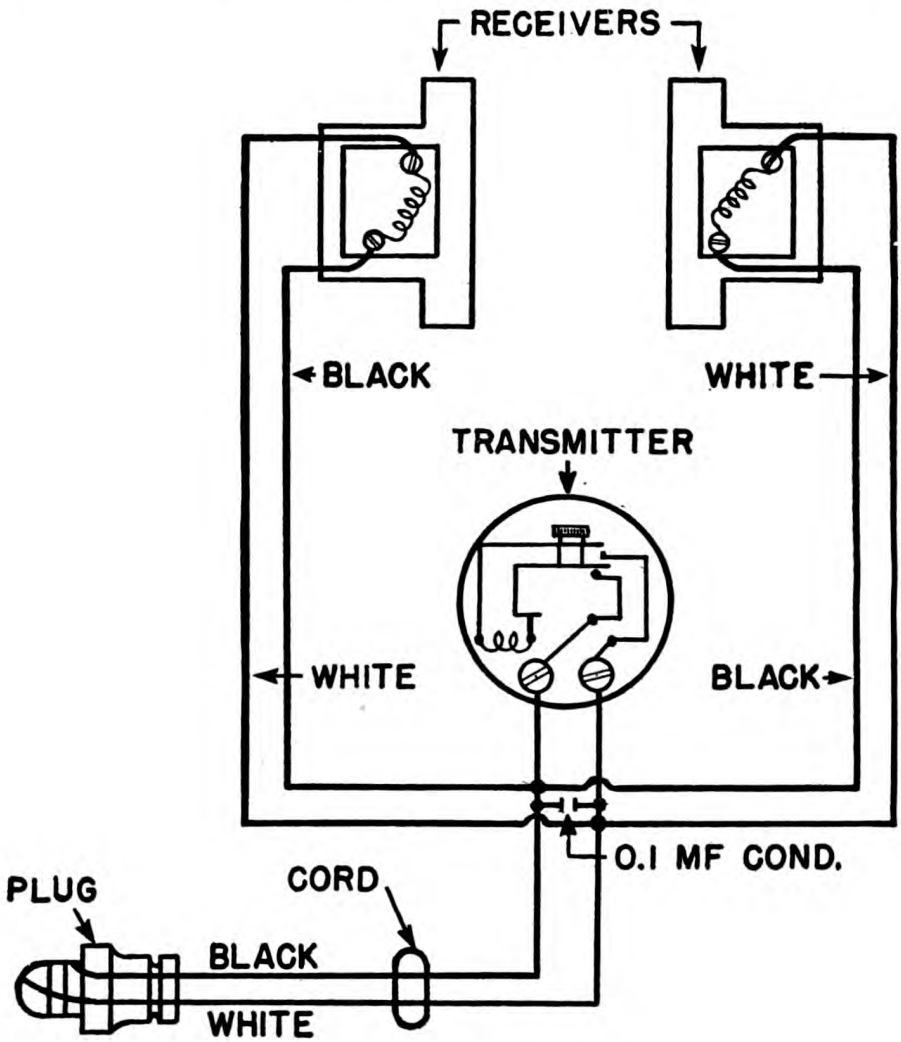


Figure 60.—Schematic diagram of sound-powered telephone.

When you sketch a wiring diagram be sure you mark the connections properly, and that you employ the proper symbols. Your diagrams must give ALL the information ACCURATELY.

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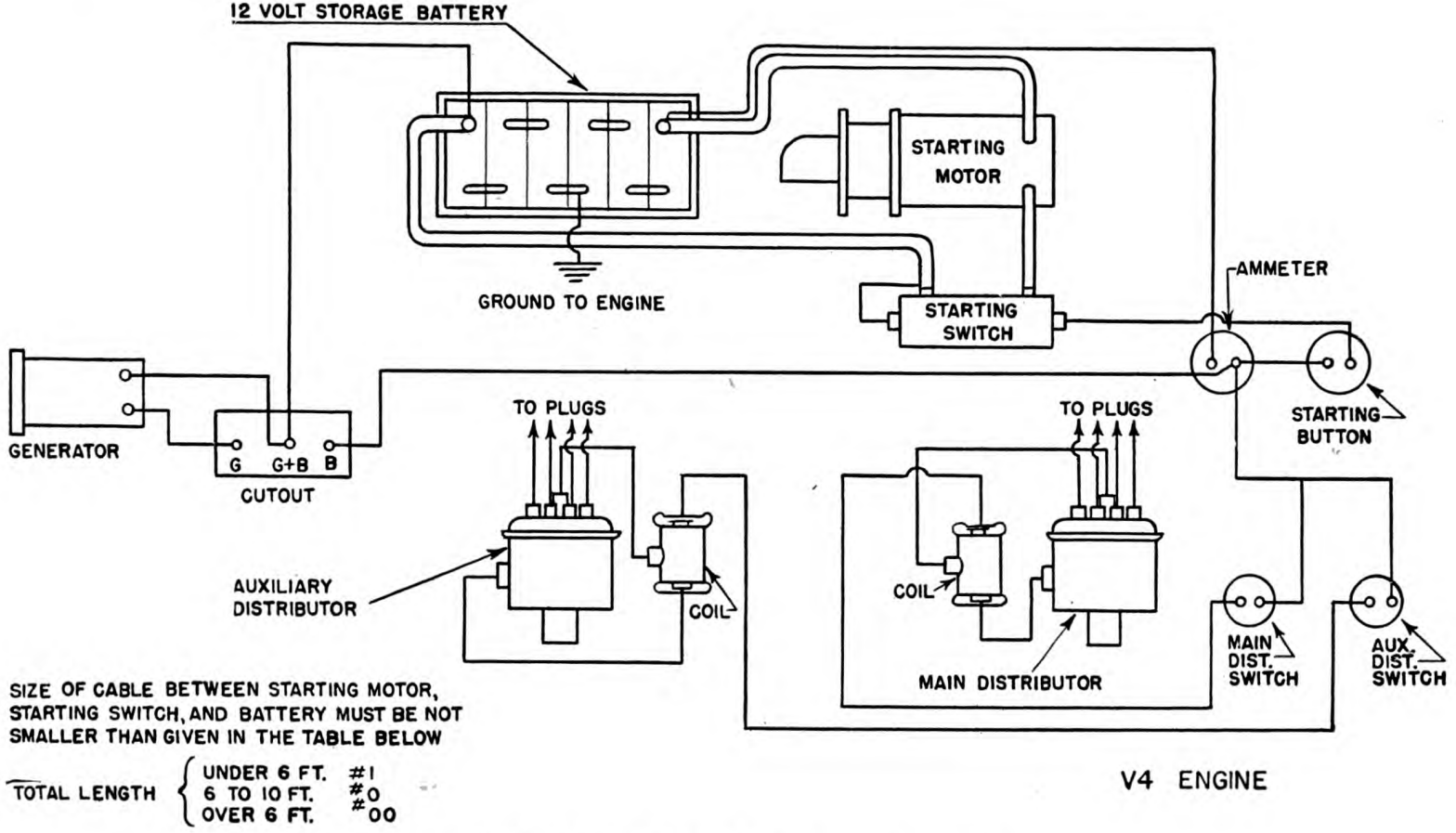
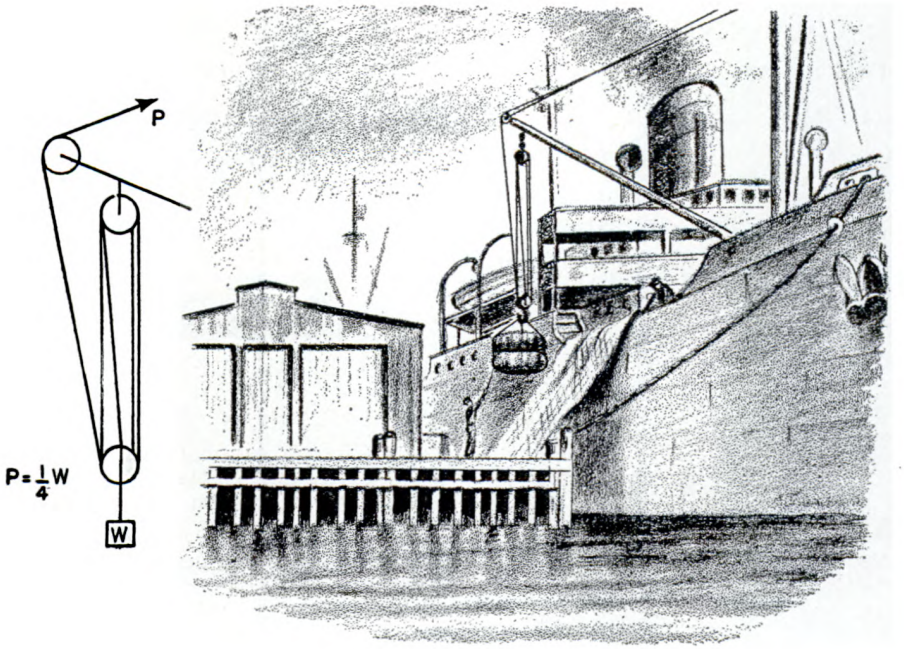


Figure 61.—Wiring diagram for V4 power boat engine.

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CHAPTER 10

READING DIAGRAMS

MECHANICAL SCHEMATIC DIAGRAMS

Aboard ship you'll find a great variety of small mechanisms. Most of these mechanisms are made up of gears, cams, screws, dials, and shafts, in numberless combinations. These mechanisms are able to do work quickly and accurately that you could never perform without them.

Some of these machines perform arithmetical calculations and solve problems instantly—problems that would take you many minutes of pencil-scribbling and head-scratching.

These mechanisms may have hundreds of small parts. If the draftsman showed them as they actually look, you couldn't make "head-nor-tail" of them. By using a SCHEMATIC DIAGRAM, he can easily show the relationships of the various parts and their function and operation.

The diagram in figure 62 shows a simple mechan-

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ism connected to a ship's speed indicator. Note the symbols in the legend and how they are used on the diagram. Notice that the gears are described by P and T. P is the PITCH or number of gear teeth per

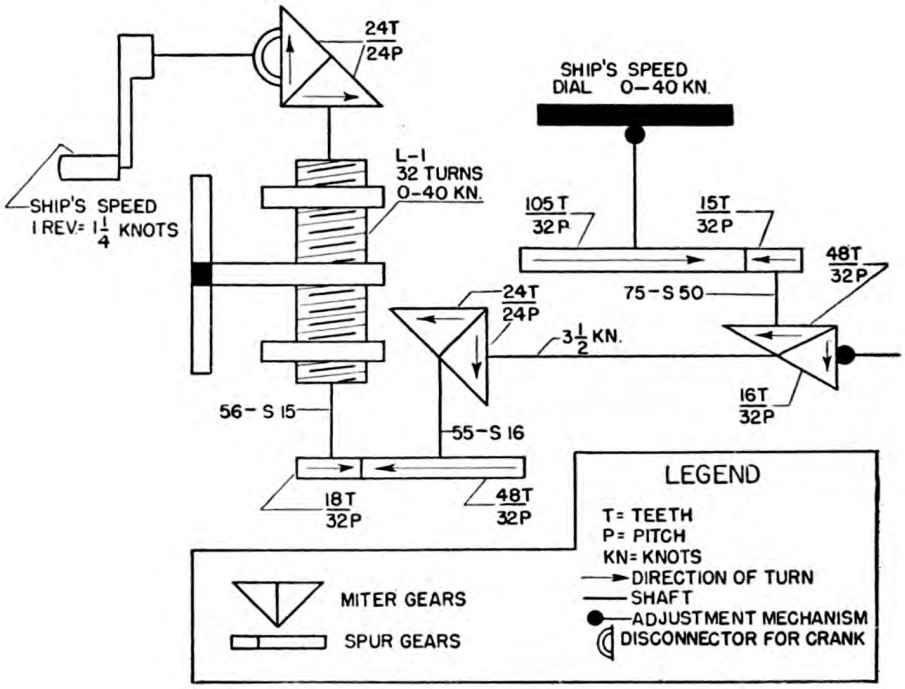


Figure 62.—Schematic diagram of a mechanism.

inch. T is the number of teeth on that particular gear. See if you can trace the mechanism through from the crank to the dial.

Fire controlmen, gunner's mates, and torpedomen will often have need to read mechanical schematics, like the one of a rangekeeper shown in figure 63. The purpose of this type of diagram is to show how certain STANDARD MECHANICAL UNITS are hooked up together. These standard units are represented by special SYMBOLS, and the man who uses the drawing is supposed to have previous knowledge as to how the unit works.

For example, the sliding device, shown at the lower left, is a MULTIPLIER. It is a mechanical linkage with three shafts coming out of it. Two are drive shafts,

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usually called INPUTS; one is a driven shaft, or OUTPUT. If one of the drive shafts turns 10 times and the other drive shaft turns 2 times, the driven shaft will turn 10×2 or 20 times.

Each little circle, with an $\times$ inside, represents a DIFFERENTIAL GEAR. These gear assemblies are so arranged that if two gears are turned, the third will move as much as the combined movement of the other two.

Other devices pictured with symbols are the two integrators in the upper corners, two component solvers, a computing cam, dials, and hand cranks.

The lines joining the symbols are the important part of the diagram. Each line indicates the existence of a mechanical connection. It does not identify the connection—it may be a single gear or it may be a complicated arrangement of many gears and shafts. The lines do not ordinarily represent the actual position of shafting. Instead, the lines are drawn in any conven-

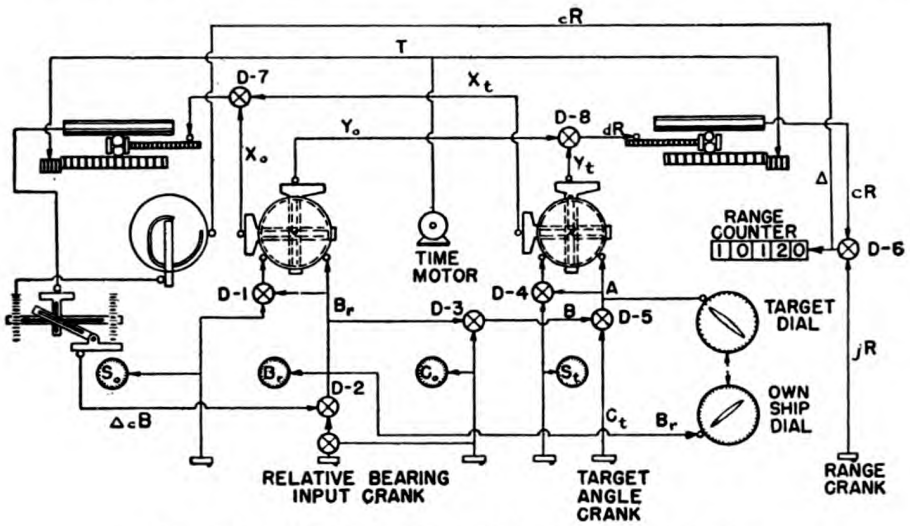


Figure 63.—Mechanical schematic of a rangekeeper.

ient location, like the lines of an electrical wiring diagram.

The mechanism illustrated, a simple rangekeeper, is a computing device used in fire control. If proper values of your own ship's speed and course, target

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ship's speed and course, and initial range and bearing of the target are cranked into the rangekeeper, the range-counter dial will continue to show the correct range between the moving ships as long as the time motor continues to run.

PIPING SYSTEMS

If you played basketball or football in school, you used schematic diagrams. The coach drew the diagrams. He showed the location of the players' positions by small circles and their movements by lines and arrows. The draftsman uses similar diagrams to show the ship's fresh water system, lubrication systems, fuel oil systems, refrigeration system, and drainage systems.

The secret of using these schematic diagrams is knowing and recognizing the SYMBOLS. Most of these symbols are standardized. If any unusual symbols are found on the diagram, you'll find an explanation in the LEGEND.

Study the diagrams, figures 64, 65, 66, and 67.

Don't be disappointed if the pipes don't look exactly like the diagram. If they did, it would be a mechanical drawing and not a diagram. The diagram will clearly indicate location of VALVES, VENTS, GAGES, TANKS, PUMPS, etc. It will show the DIRECTION of FLOW of the liquid or steam in the pipes and tell WHAT KIND of substance it is.

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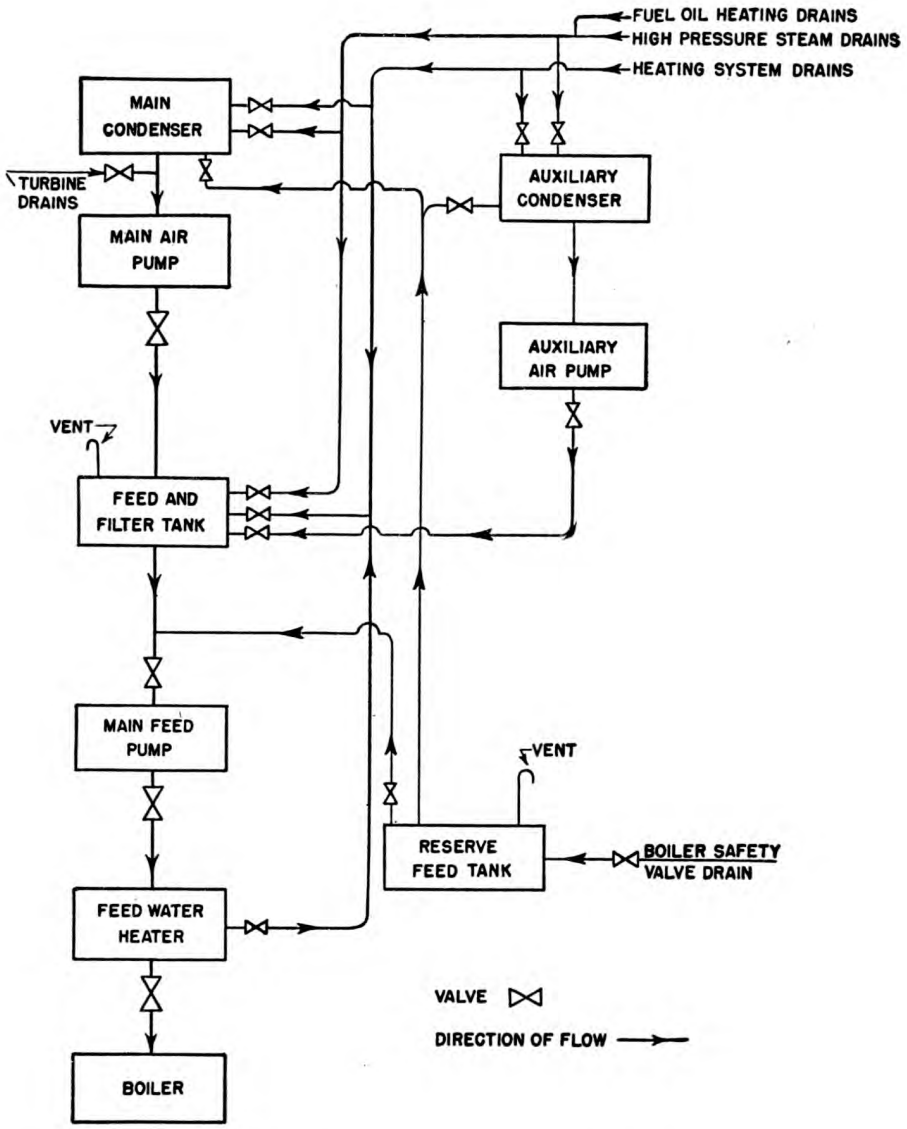


Figure 64.—Open feedwater system for boilers.

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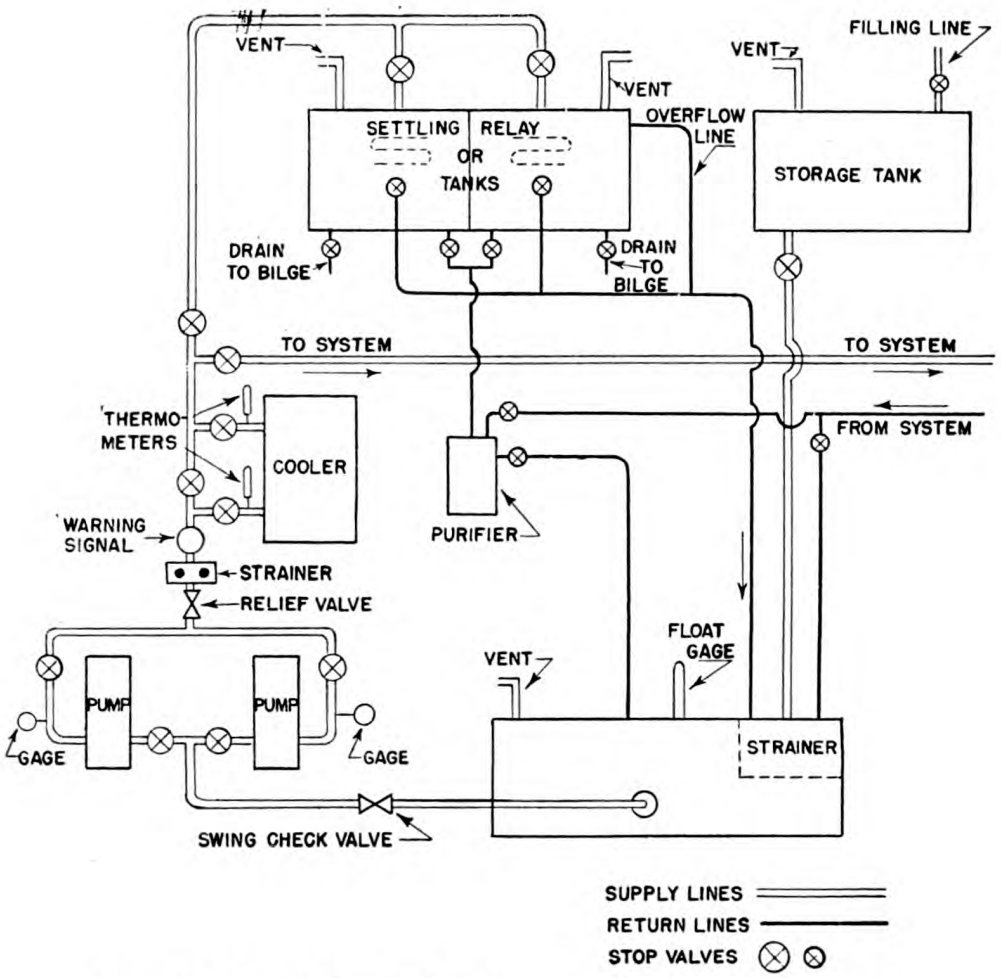


Figure 65.—Typical forced lubrication system found on naval vessels.

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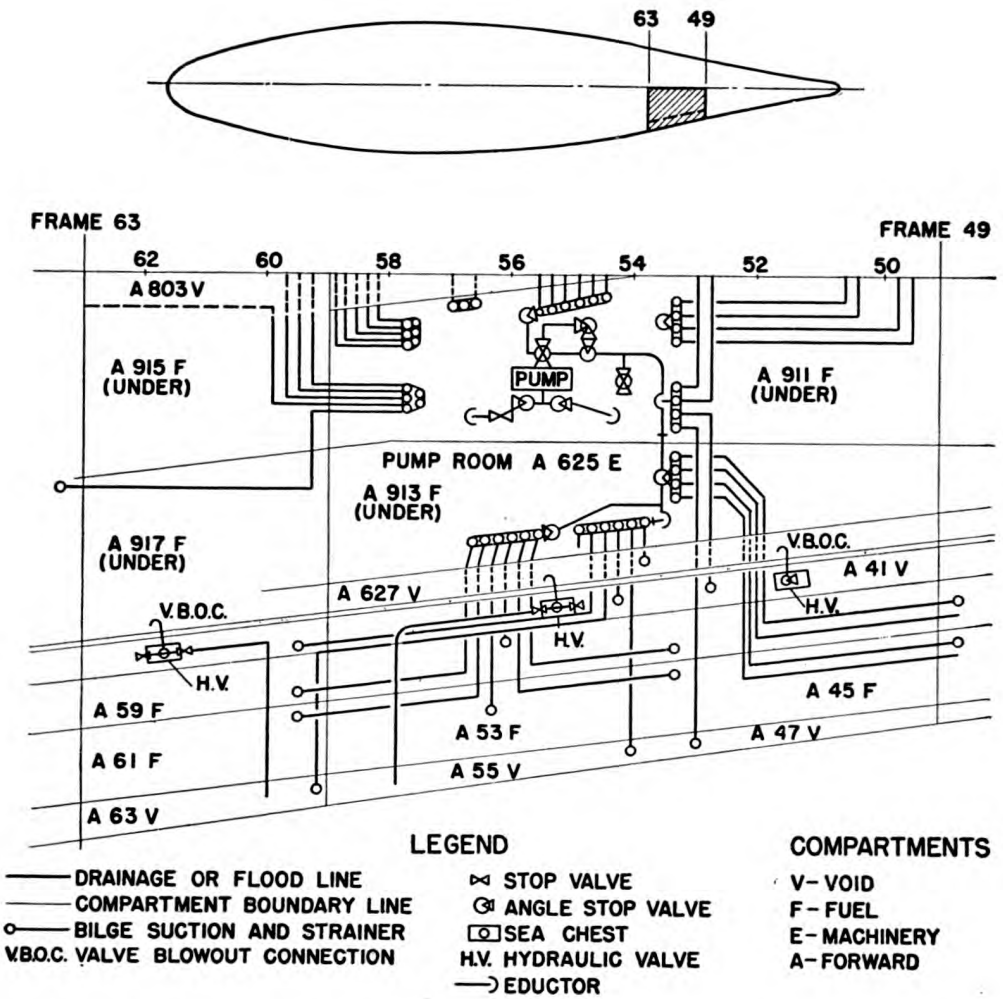


Figure 66.—Detailed sketch of draining and flooding system, NORTH CAROLINA class battleships.

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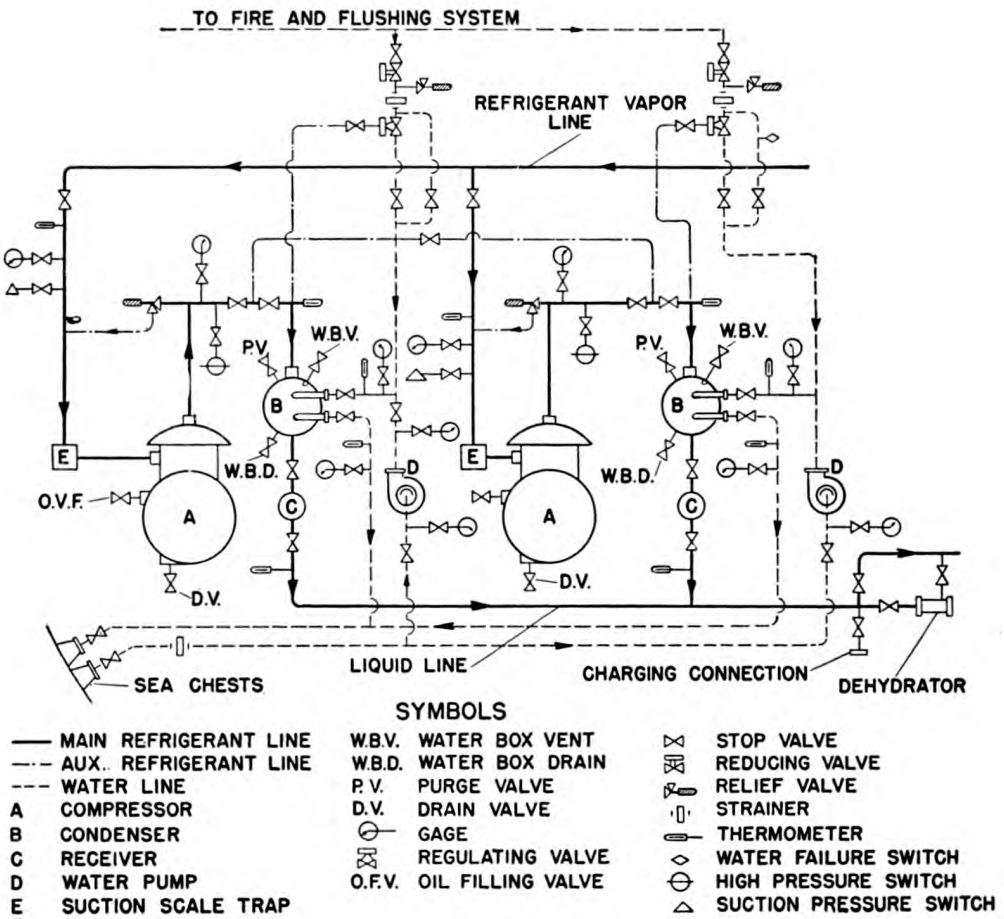


Figure 67.—Diagram of ship refrigeration system.

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APPENDIX I

ABBREVIATIONS IN COMMON USE

ACT.	actual
ADJ.	adjustable
ALC.	Alclad
ALT. POS.	alternate position
ALUM.	aluminum
AMM.	ammunition
A.N.	Army-Navy
APPROX.	approximately
ASS'Y.	assembly
AUX.	auxiliary
A.W.G.	American Wire Gage
B.	bore
B.C.	bolt center
B.L.	bend line
BLKD.	bulkhead
B/M	bill of material
B/P	blueprint
BR.	brass
B & R	bore and ream
BRG.	bearing
B. & S.	Brown and Sharpe Gage
B.W.G.	Birmingham Wire Gage
BZ.	bronze
CAP.	capacity
CARB.	carburize
C. BORE	counterbore
C.C.	center-to-center
CHK., CK.	check
CHNG.	change
CHR.	chromium
C.I.	cast iron
CIR.	circumference
C.	centerline
CNTBR.	counterbore
CONDT.	conduit
C.R.S.	cold rolled steel
CSK.	countersink
CSK. HD.	countersunk head
C.T.	contour template
CTR.	center
CU.	copper
D.	drill
D., DIA.	diameter
DEV.	development
DIM.	dimension
DN.	down
D & R	drill and ream
DWG.	drawing
DUP.	duplicate
EA.	each
F.A.O.	finish all over
F.H.	flat head
FIG.	figure
FIL.	fillet
FIL. HD.	fillister head
FIN.	finish
FIT.	fitting
FLG.	flange
FR.	front, frame
G.	grind
GA.	gage
G.I.	galvanized iron
HD.	head
HEX.	hexagonal
HG.	mercury

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HOR.	horizontal
H.P.	horsepower
H.S.ST.	high speed steel
H.T.	heat treat
HYD.	hydraulic
I.D.	inside diameter
L.	left
LENG.	length
LG.	long
LTG.H.	lightening hole
MACH.	machine
MAT'L.	material
MAX.	maximum
MED.	medium
MIN.	minimum
MISC.	miscellaneous
MK.	mark
M.L.	mold line
MM.	millimeters
MOD.	modification
M.P.H.	miles per hour
M.S., MCH.SC.	machine screw
MTG.	mounting
N.C.	National Coarse thread
N.FORM	National Form thread
N.F.	National Fine thread
N.G.F.	Naval Gun Factory
N.P.T.	National Pipe thread
NO. REQ.	number required
N.T.S.	not to scale
OBS.	obsolete
O.C.	on center
O.D.	outside diameter
OPP.	opposite
ORD.	ordnance
ORD. ALT.	ordnance alteration
O.S. UP	other side up
O.V.	over-all
PH. BZ.	phosphor bronze
PL.	plate
P.S.I.	pounds per square inch
P.T.	pipe thread
R.	right, radius
RD.	round
RD. HD.	round head
REF.	reference
REINF.	reinforce
REQ.	required
R.H.	right hand
RIV.	rivet
R.L.	reference line
R.P.M.	revolutions per minute
RR.	rear
S.A.E.	Society of Automotive Engineers
SECTN.	section
SER.	serial number
SHN.	shown
S.L.	stock length
S.L.T.	steel layout template
SN.	tin
SPEC.	specification
SQ.	square
S.S.	semi-standard
STA.	station
STD.	standard

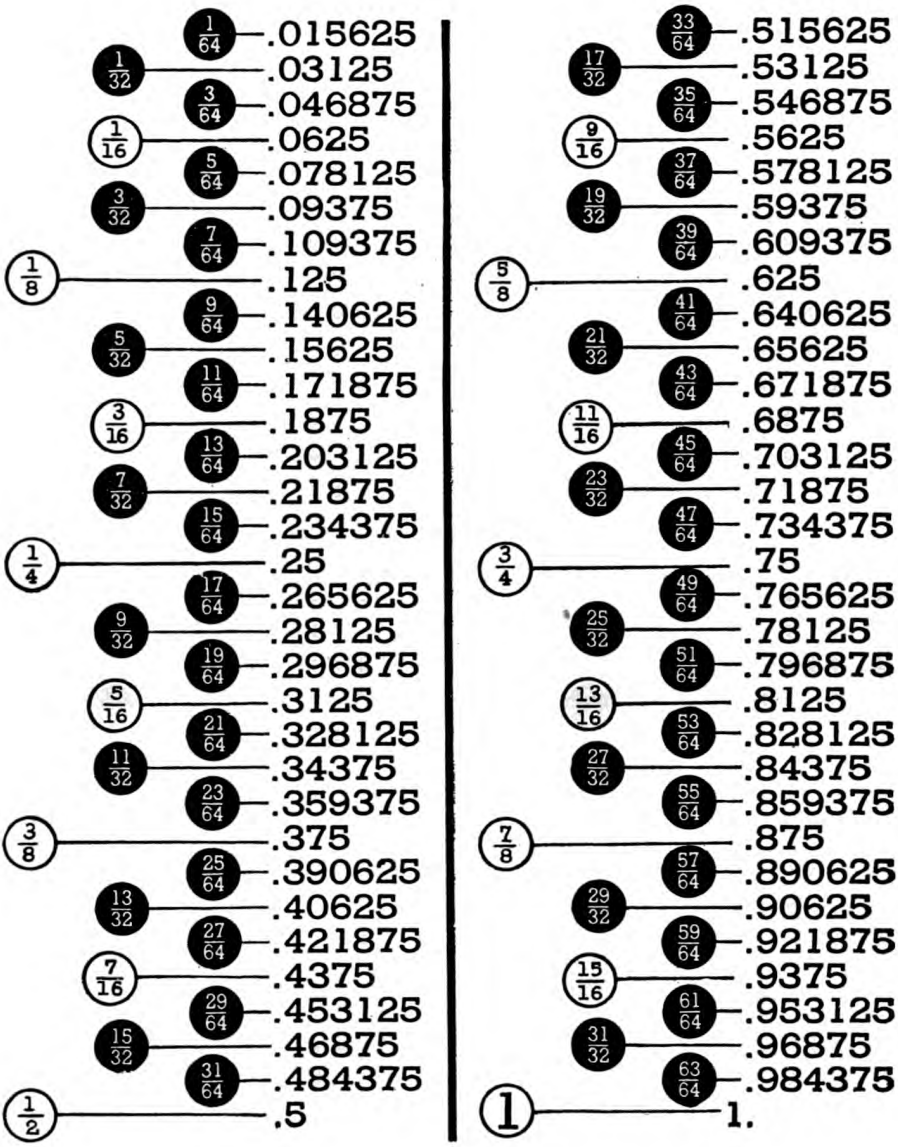
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STL.	steel	T.L.	true length
SUP.	support	TOL.	thickness
S.W.	stock width	T.S. UP	tolerance
SYM.	symetrical, symbol	THK., TK., T.	this side up
		UNF.	unfinished
T.	thickness	U.S.S.	United States Standard
TAN.	tangent		
TEMP.	template, temperature	VERT.	vertical
		W.	width
TEN. STR.	tensile strength	W.L.	water line
THD.	thread	X.	experimental

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APPENDIX II

FRACTIONS & DECIMAL EQUIVALENTS



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APPENDIX III

TWIST DRILL SIZES

Size	Decimal equivalents	Size	Decimal equivalents	Size	Decimal equivalents
1/2	0.5000	C	0.2420	30	0.1285
31/64	.4844	B	.2380	1/8	.1250
15/32	.4687	15/64	.2344	31	.1200
29/64	.4531	A	.2340	32	.1160
7/16	.4375	No. 1	.2280	33	.1130
27/64	.4219	2	.2210	34	.1110
Z	.4130	7/32	.2187	35	.1100
13/32	.4062	3	.2130	7/64	.1094
Y	.4040	4	.2090	36	.1065
X	.3970	5	.2055	37	.1040
25/64	.3906	6	.2040	38	.1015
W	.3860	13/64	.2031	39	.0995
V	.3770	7	.2010	40	.0980
3/8	.3750	8	.1990	41	.0960
U	.3680	9	.1960	3/32	.0937
23/64	.3594	10	.1935	42	.0935
T	.3580	11	.1910	43	.0890
S	.3480	12	.1890	44	.0860
11/32	.3437	3/16	.1875	45	.0820
R	.3390	13	.1850	46	.0810
Q	.3320	14	.1820	47	.0785
21/64	.3281	15	.1800	5/64	.0781
P	.3230	16	.1770	48	.0760
O	.3160	17	.1730	49	.0730
5/16	.3125	11/64	.1719	50	.0700
N	.3020	18	.1695	51	.0670
19/64	.2969	19	.1660	52	.0635
M	.2950	20	.1610	1/16	.0625
L	.2900	21	.1590	53	.0595
9/32	.2812	22	.1570	54	.0550
K	.2810	5/32	.1562	55	.0520
J	.2770	23	.1540	3/64	.0469
I	.2720	24	.1520	56	.0465
H	.2660	25	.1495	57	.0430
17/64	.2656	26	.1470	58	.0420
G	.2610	27	.1440	59	.0410
F	.2570	9/64	.1406	60	.0400
E 1/4	.2500	28	.1405		
D	.2460	29	.1360		

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APPENDIX IV
STANDARD WIRE GAGES

	Spring steel, flat wire, strip steel, steel tube, aluminum tube, brass tube	Nickel silver, copper, aluminum,* brass	Steel sheet, steel plate, nickel sheet, Monel metal	Steel wire, iron wire	Music wire
Gage No.	Birmingham or Stubs	American or B. & S.†	U. S. Standard	Washburn & Moen	Music wire Standard
6/0		0.5800	0.4687	0.4615	0.004
5/0		.5165	.4375	.4305	.005
4/0	0.454	.4600	.4062	.3938	.006
3/0	.425	.4096	.3750	.3625	.007
2/0	.380	.3648	.3437	.3310	.008
1/0	.340	.3249	.3125	.3065	.009
1	.300	.2893	.2812	.2830	.010
2	.284	.2576	.2656	.2625	.011
3	.259	.2294	.2500	.2437	.012
4	.238	.2043	.2343	.2253	.013
5	.220	.1819	.2187	.2070	.014
6	.203	.1620	.2031	.1920	.016
7	.180	.1443	.1876	.1770	.018
8	.165	.1285	.1718	.1620	.020
9	.148	.1144	.1562	.1483	.022
10	.134	.1019	.1406	.1350	.024
11	.120	.0907	.1250	.1205	.026
12	.109	.0808	.1093	.1055	.029
13	.095	.0719	.0937	.0915	.031
14	.083	.0640	.0781	.0800	.033
15	.072	.0570	.0703	.0720	.035
16	.065	.0508	.0625	.0625	.037
17	.058	.0452	.0562	.0540	.039
18	.049	.0403	.0500	.0475	.041
19	.042	.0359	.0437	.0410	.043
20	.035	.0319	.0375	.0348	.045
21	.032	.0284	.0343	.0317	.047
22	.028	.0253	.0312	.0286	.049
23	.025	.0225	.0281	.0258	.051
24	.022	.0201	.0250	.0230	.055
25	.020	.0179	.0218	.0204	.059
26	.018	.0159	.0187	.0181	.063
27	.016	.0142	.0171	.0173	.067
28	.014	.0126	.0156	.0162	.071
29	.013	.0112	.0140	.0150	.075
30	.012	.0100	.0125	.0140	.080
31	.010	.0089	.0109	.0132	.085
32	.009	.0079	.0101	.0128	.090
33	.008	.0071	.0093	.0118	.095
34	.007	.0063	.0085	.0104	.100
35	.005	.0056	.0078	.0095	.106
36	.004	.0050	.0070	.0090	.112
37		.0044	.0066	.0085	.118
38		.0039	.0062	.0080	.124

*Except Aluminum Tubing. †B. & S. is Brown & Sharpe.

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How Well Do You Know—

USE OF BLUEPRINTS

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QUIZ

CHAPTER 1

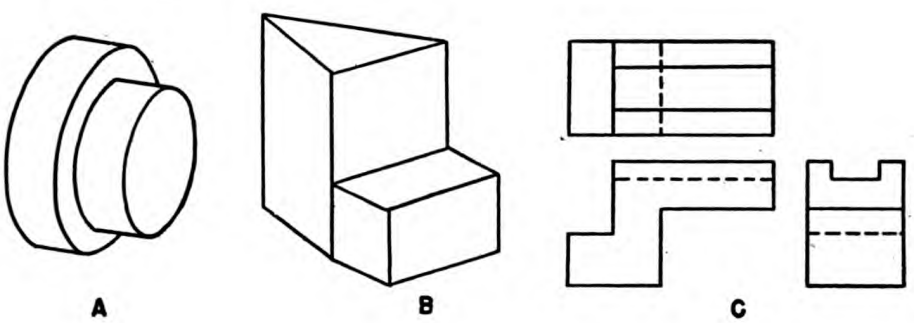
BACKGROUND FOR BLUEPRINTS

1. What are the blueprints called that show the compartments of a ship?
2. What color are the lines of a blueprint?
3. If a necessary line dimension were missing from your blueprint, why couldn't you just measure the line on it?
4. What kind of print would you use as a guide for constructing a replacement part for a gun mount?
5. Blueprints are used to save mechanical drawings. What kind of care must you exercise to save blueprints?

CHAPTER 2

IT'S ALL HOW YOU LOOK AT IT

1. Why can't you use a photograph of an object as a blueprint when you make a replacement part for a machine?
2. What is another name for exploded views?
3. What lines of an isometric drawing are true in length?
4. Mechanical perspectives are very much like photographs. When is the perspective used because it is impossible to use a photograph?
5. Why are orthographic drawings universally used as blueprints for construction?
6. What type of surface requires an auxiliary projection?
7. Sketch two orthographic views of *A*, three views of *B*, and an isometric of *C*.

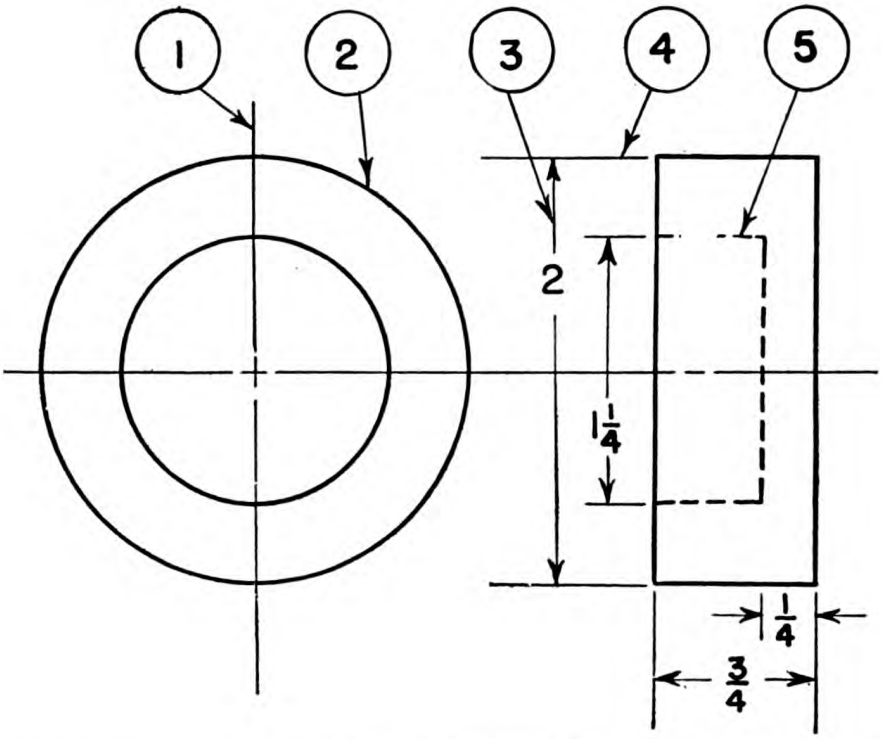


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CHAPTER 3

LINES AND SECTIONS

1. Number your paper from 1 to 5 and jot down the names of the five lines in the accompanying illustration.



2. What material symbol is often used to indicate all metals, except lead and babbitt?
3. What kind of section is shown as a drawing within a drawing?
4. The line running from a note to the indicated position is called what?

CHAPTER 4

THE WORKING DRAWING TELLS EVERYTHING

1. If the length of a shaft is specified as $8\frac{1}{2}$ inches and the tolerance $\pm 1/64$ inch, what is the lower limit of accuracy? The upper limit?
2. What class of fit, between shaft and bearings, would you use for extremely accurate, slow moving parts?

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3. A note for a threaded rod reads ¼—28 NF—3. What does this "draftsman's shorthand" mean?
4. What system of dimensioning helps you avoid accumulative errors when laying out the outline of an object?
5. How many points should you measure from to secure an accurate layout?

CHAPTER 5

READ IT YOURSELF

1. Drawings used for construction are remarkably accurate and complete. What is done to the completed drawing to insure this accuracy?
2. Why is a number stamped, cast, or stenciled on each part of a machine or engine?
3. When you're unable to understand part of a drawing what should you do about it?
4. What characteristic or quality is imparted to hard steel by the tempering process?

CHAPTER 6

RULES FOR LAYOUT TOOLS

1. What tool would you use to lay out an angle of 34°?
2. A set of trammel points might be called the big brother of what tool?
3. Why is it good layout practice to measure from the one-inch mark of the rule rather than from the end?
4. What two marking tools are most commonly used when layouts are made on sheet steel?
5. How do the center punch and the prick punch differ?
6. Centerlines on a blueprint are alternate long and short dashes. How are they shown on a layout?
7. When should you use a pencil for marking layouts?
8. What tool can be used to guide the scriber for marking small irregular curves?

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CHAPTER 7

LAY IT OUT

1. Most pieces of stock have three dimensions. List them in order as they appear in a bill of material.
2. Accuracy of a layout is partly dependent on the correct use of the combination square. What condition of the stock must exist before the square can do an accurate job?
3. What is the chief purpose of using layout fluid?
4. How does a reference line differ from a reference edge?
5. What procedure method did you use to lay out the anchor plate, figure 44?
6. List two uses of prick punch marks.
7. When you complete a layout and it checks out OK, what should you do next?

CHAPTER 8

TIN-BENDER SPECIALS—DEVELOPMENTS

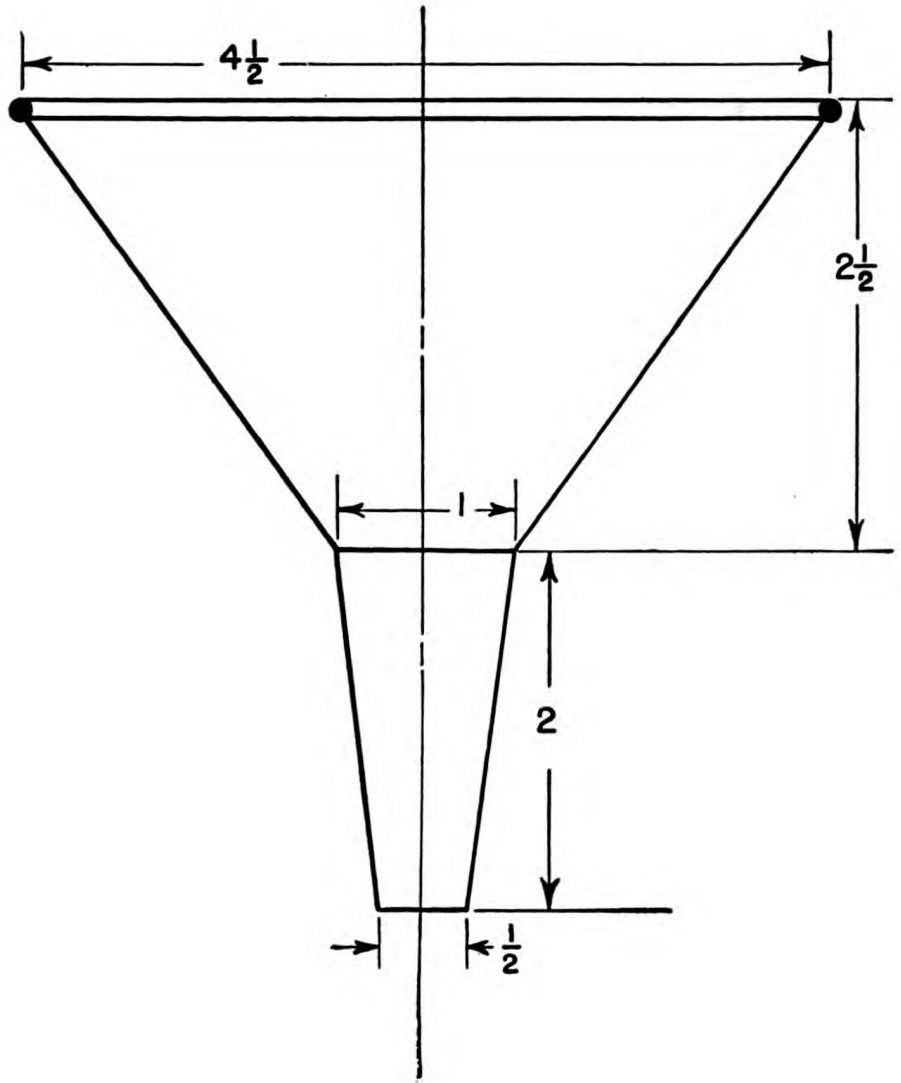
1. What development method is used to make the pattern for a funnel?
2. Make the developments for the body and the spout of the funnel at the top of page 121. Allow 5/16″ to cover the wire around the top. For the seam allowance, add 3/16″ to one edge and 7/16″ to the other edge.
3. Develop the pattern for the body of the powder scoop on page 121. It requires the same seam allowance as the funnel.

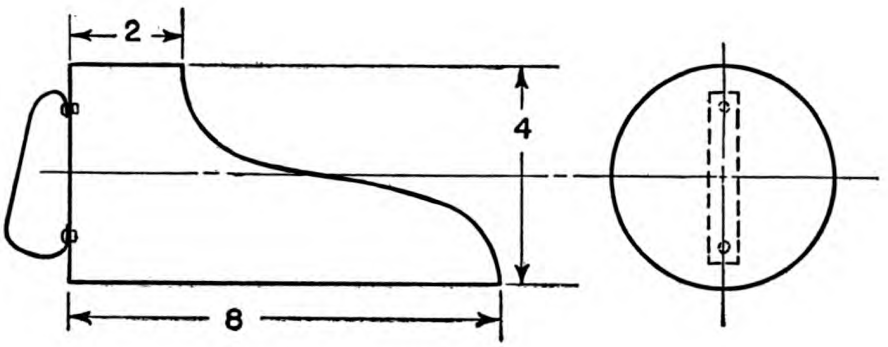
CHAPTER 9

ELECTRICAL BLUEPRINTS

1. What are the two types of electrical diagrams?
2. Where two wires cross, how is a connection shown?
3. What are the symbols for these items?
 a. motor, (A.C.).
 b. ground.
 c. voltmeter.
 d. generator, (A.C.).
 e. arc.
 f. fuse.

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CHAPTER 10

READING DIAGRAMS

1. When the letter "T" is used on a gear diagram, what does it mean?
2. How is the direction of flow in a pipe indicated on a diagram?
3. Machinery compartments on a ship are indicated by what capital letter?
4. What is the symbol for a gage?

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ANSWERS TO QUIZ

CHAPTER 1

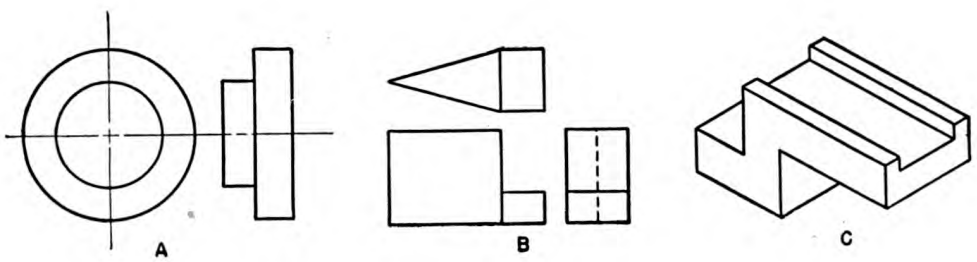
BACKGROUND FOR BLUEPRINTS

1. Plan views.
2. White, unless it's an ammonia print.
3. Distance should never be measured on a blueprint, because of three possible sources of error—
 Original inaccuracy of draftsman.
 Stretching of blueprint paper.
 Shrinkage of blueprint paper.
4. A detail print of that part.
5. Protect them from dampness, grease, and strong sunlight.

CHAPTER 2

IT'S ALL HOW YOU LOOK AT IT

1. The photograph is not accurate. It does not show true shape or size.
2. Train views. The parts of an assembly or sub-assembly are spread out on the paper like cars on a railroad track.
3. The lines of the isometric representing the horizontal and vertical lines of the object are true in length.
4. Mechanical perspectives are used to provide pictures of objects not yet constructed.
5. They are accurate. The lines of orthographic projection views indicate the true size and shape of the object drawn.
6. An inclined or slant surface.
7.



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CHAPTER 3

LINES AND SECTIONS

1. The names of the lines are:
 (1) Centerline.
 (2) Object outline.
 (3) Dimension line.
 (4) Extension line.
 (5) Hidden line.
2. The symbol for cast iron. See figures 20 and 21.
3. Revolved section.
4. Leader.

CHAPTER 4

THE WORKING DRAWING TELLS EVERYTHING

1. 8-31/64; 8-33/64.
2. Class 3 fit (snug fit).
3. ¼—outside diameter of thread in inches.
 28—thread pitch (thread points per inch).
 NF—National Fine Threads used.
 3—Class 3 thread fit (medium fit).
4. Base-line dimensions.
5. One and only one. It's your base point.

CHAPTER 5

READ IT YOURSELF

1. The accuracy of a drawing is secured by checking and rechecking. If it's important, four or more experts will check it.
2. For identification during assembly and to speed up replacement of broken parts.
3. Ask the man who knows, one of the senior petty officers in your division.
4. Toughness.

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CHAPTER 6

RULES FOR LAYOUT TOOLS

1. Bevel protractor.
2. Dividers.
3. The end of the rule may be worn off, making the first inch mark actually less than an inch from the end.
4. Scriber; dividers.
5. The center punch is usually larger than the prick punch. The center punch point angle is 90° as compared to the 30° angle of the prick punch.
6. As sharp fine lines. All layout lines should be alike, narrow, of uniform width, and clear-cut.
7. When the material is wood or aluminum.
8. French curve.

CHAPTER 7

LAY IT OUT

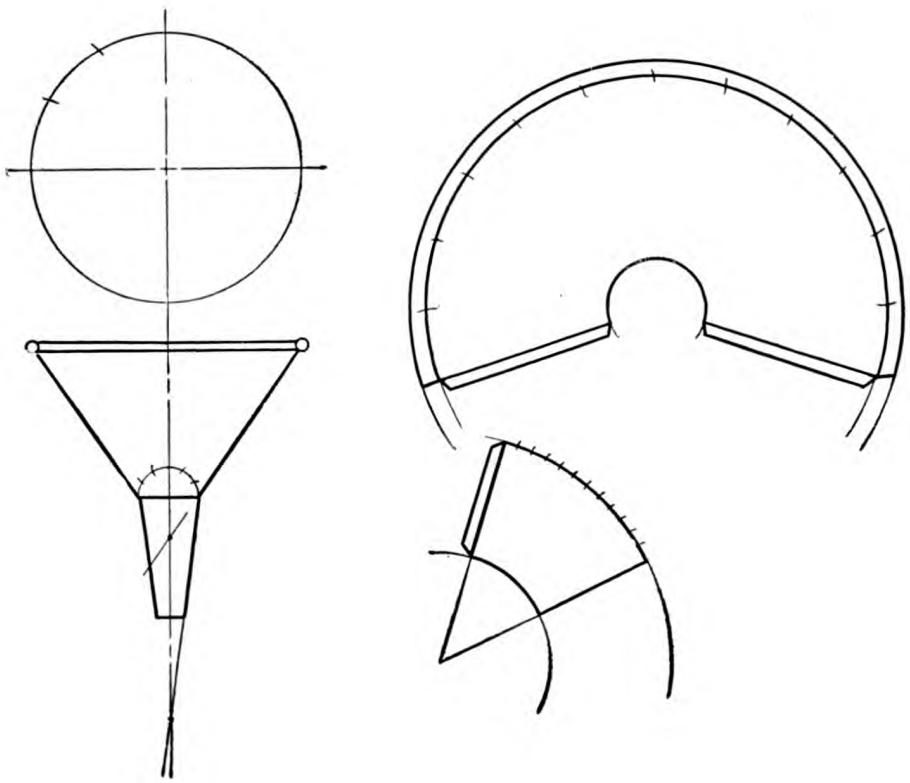
1. Thickness, width, length.
2. The stock should have one squared edge and one squared end.
3. To provide a background against which your layout lines will show up clearly.
4. The reference line must be on the surface of the layout, the reference edge cannot be on the surface.
5. Basic centerline method.
6. Prick punch marks locate the centers of drilled holes and provide pivot points for swinging arcs.
7. Put up those layout tools. Keep them in good condition at all times.

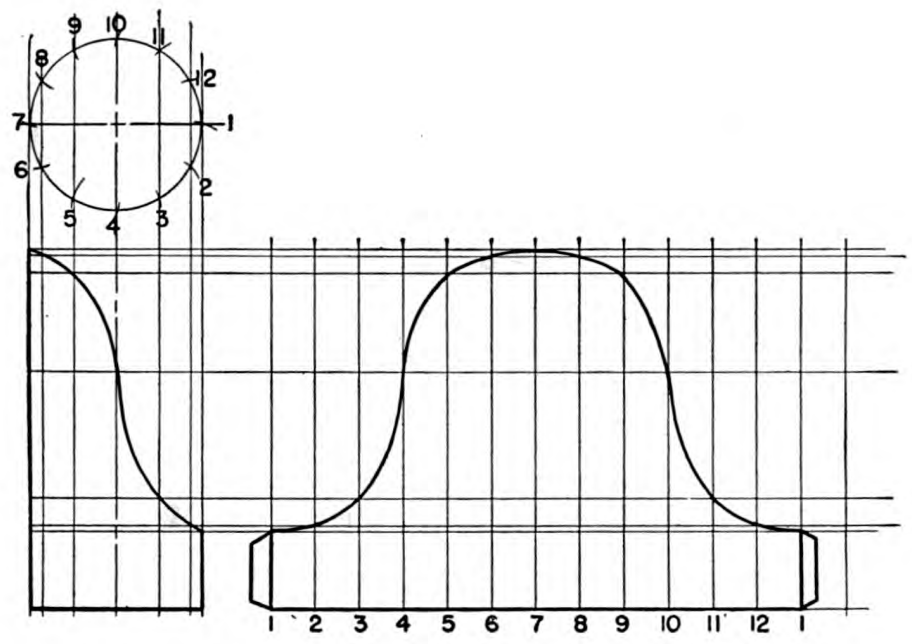
CHAPTER 8

TIN-BENDERS SPECIALS—DEVELOPMENTS

1. Radial development.
2. See drawing at top of page 126.
3. See drawing, bottom of page 126.

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CHAPTER 9

ELECTRICAL BLUEPRINTS

1. Wiring diagrams, schematic diagrams.
2. The connection is indicated by a dot on the intersection. No dot—no connection.
3. Check your answers against figure 58.

CHAPTER 10

READING DIAGRAMS

1. "T" means total number of teeth on the gear.
2. By a small arrow.
3. E.
4. A small circle with an arrow inside. See figure 65.

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